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MEMOIRS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Palæontologia Indica,

BEING

FIGURES AND DESCRIPTIONS OF THE ORGANIC REMAINS PROCURED DURING THE PROGRESS OF THE GEOLOGICAL SURVEY OF INDIA.

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Ser. XIII.

SALT-RANGE FOSSILS.

Vol. I.

PRODUCTUS LIMESTONE FOSSILS.

By WILLIAM WAAGEN, Ph.D., F.G.S.,

Ober Bergrath, Professor of Mineralogy and Geology at the I. R. German Polytechnic University of Prag.

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CONTENTS.

	PAGE
Preface	i
List of Parts of Text, with dates of publication	ix
List of Plates in Parts, with dates of publication	xi
List of photozincographs	xiii
Introduction	2
Pisces	9
Crustacea	20
Cephalopoda	21
Pisces, Cephalopoda; Supplement	73
Gasteropoda	86
Pelecypoda	185
Brachiopoda	329
Bryozoa	771
Annelida	814
Echinodermata	818
Cœlenterata: Anthozoa	835
Do. : Hydrozoa	925
Supplement to the Bryozoa	963
Amorphozoa	967
Protozoa by Dr. C. Schwager	983
Index	995

PREFACE.

In finishing the last part of the extensive volume now entirely before the public, the first duty that devolves on me is to express publicly my most sincere thanks to all those who have contributed in any way to the completion of the work.

Among these my greatest thanks are due to Mr. H. B. Medlicott, Director of the Geological Survey of India, who was mainly influential in originating and in sustaining the work. Upon him too fell the task of correcting all the proofs, seeing them through the Press, and editing the whole. I am glad to be able to express this gratitude to him publicly, just at the time when he is about to retire from his service in India. The volume now completed, and the numerous other volumes of the Palæontologia Indica published since 1876, show how earnestly he endeavoured to make his Directorship as fruitful as possible to the Geological Survey of India.

Whilst Mr. Medlicott had a principal influence in the publication of this volume, there were several others who had more or less influence on its contents. Among these were two who, in the meantime, have gone away from among us, Thomas Davidson and Prof. King of Galway.

Who could ever have been engaged on the description of Brachiopoda without coming into personal relations with Mr. Davidson? and who could have had that experience without being struck with the extreme amiability of that learned author. Notwithstanding the great amount of work that he always had in hand, yet he invariably found time to answer all questions addressed to him, to write long and most instructive letters, to give long extracts from books which were not available to his correspondents, with the fullest advice whenever he could. Thus, there is a universal feeling of gratitude towards him among scientific workers by whom his death has been felt most keenly as a severe loss. It was Mr. Davidson who brought about a long correspondence between Prof. King and myself.

Prof. King, it cannot be doubted, was one of the most eminent Palæontologists England ever possessed, and it must be a permanent regret that his palæontological publications were, besides his classical work on the Permian fossils, so limited in number. His letters, addressed to me

regarding some difficult cases I had to treat of in the class of the Brachiopoda, were of the utmost value and importance, and I am proud to be able to quote his name among those who have materially helped me in the execution of the present work. His death also has been felt as a severe loss.

Others who helped me in many ways were mentioned in the introduction to this work, but who also are now no longer among the living—Joachim Barrande and Geheimrath v. Abich. Both were most intimate friends of mine, and it is with the utmost regret that I mention them here as passed away before they could see the end of their own fundamental works.

To the list, given in the introduction (page 5), of men of science who have contributed in many ways more or less materially towards the execution of the present work, must now be added the following :—

General Intendant Hofrath v. Hauer of Vienna.
Prof. A. Tritsch of Prague.
Geheimrath Geinitz of Dresden.
Hofrath Liebe of Gera.
Geheimrath Beyrich, Prof. Dames } of Berlin.
Prof. Kayser of Marburg.
Prof. v. Zittel of Munich.
Prof. Lindström of Stockholm.
Prof. Nikitin, Prof. Lahnsen } of St. Petersburg.
Prof. Barrois of Lille.
Prof. James Hall of Albany, N. Y.
Dr. White, Palæontologist, G. S. U. S, Washington.
Prof. Worthen of Springfield, Ill.

To all these my most sincere thanks are due.

There have yet to be mentioned the labours of my fellow-workers. In this respect I must before all offer my very best thanks to Dr. Conrad Schwager of Munich, who undertook the description of the Foraminifera. His name is sufficient security for the *qua* that the work he has done will be found excellent, much better than it would have been if done by myself. To my two Assistants, Dr. Joseph Pichl and Dr. Joseph Wentzel, I am also under many obligations. Without their very material help it would have been impossible to finish the volume by the present date, and I may fairly say that their work has saved me several years of labour.

Thus, helped on to a great extent by the kind intervention of all these friends, the description of the entire fauna contained in the palæozoic beds of the Salt-range (with the exception of some things recently discovered by Dr. Warth, which I propose to describe in detail in the geological part, as they are chiefly of geological rather than of palæontological interest) has now been completed, and fills a volume of much greater extent than had ever been anticipated.

It would be extremely desirable now to enter directly upon the full discussion of the several species and their geological bearing, but the volume has extended already to such stupendous bulk that it does not seem practicable to give here all those details. This event was indeed anticipated by me when in the Introduction to the present volume I proposed to unite all the geological results in a separate volume, which would form the end of the series. A great part of the manuscript intended to form the first part of the fourth volume has already been sketched out, and it is only to be hoped that the Government will consent to the continuation of the work, so that I may be able to publish the geological results regarding the palæozoic strata at an early date.

In the Introduction to the Productus-limestone-Fossils, pp. 6—8 of the present volume, I stated my opinion that among the palæozoic strata of the Salt-range two extensive series should be distinguished: one lower, containing the "Saline series" and the "Purple sandstone" of Mr. Wynne, and one upper series, composed of the "Obolus beds (silurian)," the "Magnesian sandstone," the "Speckled sandstone," and the "lower limestone (carboniferous)" of Mr. Wynne's tables. For the upper series in general I have used the name of Productus-limestone, as the last of the members, quoted above, is the richest in fossils, and thus most conspicuous.

Thus, the whole volume receives the name "Productus-limestone-Fossils." Of subdivisions I at that time accepted five, but now, after the fossils have been described in detail, the number can be considerably augmented. The beds contained in this large series can be brought conveniently into three groups, each of which can be further subdivided. We arrive thus at the following scheme:—

I—Silicious limestone group.
- Upper Productus-limestone.
  - Topmost beds.
  - Cephalopoda bed.
  - Lower beds.
- Middle Productus-limestone.
  - Upper beds.
  - Middle beds.
  - Lower beds.

II—Speckled sandstone group.	{ Lower Productus-limestone. { Speckled sandstone.
III—Magnesian sandstone group.	{ Magnesian sandstone. { Neobolus beds.

We thus arrive altogether at twelve subdivisions, of which six are of the first and six of the second order. In the lower two groups subdivisions of a second order cannot be distinguished, as fossils are very scarce.

Of all these divisions the upper and middle Productus-limestone are richest in fossils, and thus further subdivisions can easily be separated, each having a certain number of characteristic species. If we consider the fauna contained in these divisions quite in general, it cannot be denied that its aspect is entirely carboniferous, and a superficial inspection will lead every observer to suspect the beds in which such a fauna is contained to be of carboniferous age. But, on a closer examination, one will soon find that the several species are similar but not identical with carboniferous forms. Among the smaller and less conspicuous fossils one will soon detect a number of permian species; the number increases more and more, and at last one arrives at the conviction that the fauna is in reality permian—a permian fauna that is richer in forms and richer in conspicuous species than any one that has been described up to the present in the whole world.

At the same time its close relationship to the carboniferous fauna cannot be denied; and the thought cannot quite be rejected that the singular deviation of the European permian fauna from the carboniferous type is caused more by local influence than by a thorough change of the organic life over the whole world, and that in reality the permian organic life is in by far closer connection with the carboniferous than was anticipated by Murchison.

But, though on the whole the permian age of the upper and middle Productus-limestone cannot be doubted, yet its relation in detail to the European and American permian deposits cannot be made out until the geological relations of the several species have been worked out in detail, and I cannot at present give any indications in this direction.

In the lower Productus-limestone division the number of carboniferous species increases considerably, whilst of permian species only very few are met with. We thus may be justified if we consider these beds as transitional between permian and carboniferous and about corresponding in age to the sandstones of Artinsk, or to the beds of Nebraska city.

Regarding the beds still lower in position but very few indications as to their real age have come to light from the study of the fossils. I have tried to make it probable from the relations of the forms contained in the Neobolus-beds that these also were of carboniferous age; but this view was only reluctantly accepted, and from time to time objections were made against such a supposition.

I should not have been able to bring forward any new views in the matter were it not that my friend Dr. H. Warth has recently made some discoveries in the Salt-range, placing the whole question in a new light.

Some time ago in the Salt-range he detected in glacial deposits, included by Mr. Wynne in his "Olive Group," roundish nodules containing a rich fauna. I have given a preliminary notice of these contents in the Records, Geological Survey of India for last year, when I came to the conclusion that the species were partly identical with some fossils of the Australian carboniferous beds, and that they indicated with great probability a carboniferous age for the beds of the Salt-range in which they were found. Moreover, I brought the glacial deposit in which these nodules had been found into connection with other glacial deposits, which were not of rare occurrence in the Salt-range, and which generally were met with on the horizon of the speckled sandstone, and I arrived at the suggestion that both were of about the same geological age. All these suggestions were strongly and with some animosity objected to by Mr. R. D. Oldham, and the further conclusions I had drawn from all this were treated by him with contempt.

In the meantime, Dr. Warth continued his investigations with much success, and in a paper printed in the Records, 1887, part 2, page 117, he published the results of his new studies. What I had anticipated about two years ago, that the *Conulariæ*, when they were present in the Western Salt-range, could only be found there in the speckled sandstone (Wynne), has been fully proved now. Dr. Warth has traced the Conularia-bed into the Nila Wán, where he found the boulder-bed with *Conulariæ* underlying the sandstones of the lower Productus-limestone, which there make their first appearance. The boulder-bed itself has its position at the base of the speckled sandstone.

Dr. Warth, therefore, does not hesitate to place the boulder-bed of the Olive series and that of the speckled sandstone on the same horizon and to correlate with these the remaining boulder-beds of the Salt-range, all which he brings under the heading "crystalline boulder series"—a

proceeding which I consider most appropriate. With this, it seems to me, a definite proof is now attained, that the speckled sandstone for its whole extent, or, as I perhaps should rather say, the crystalline boulder series, is of the age of the upper coal-measures.

Though this is a discovery of great importance in many respects, for which science will be greatly indebted to Dr. Warth, yet the question of the exact age of the Neobolus-beds has not yet been brought to a definitive solution by it. Nevertheless, it cannot be denied, that this discovery has at least a certain bearing upon that question. Up to the present it has always been possible for those, who did not wish to accept my views in this respect, to pronounce the speckled sandstones as an equivalent of the lower carboniferous, wherewith it would have been necessary to declare the lower following beds as older than carboniferous, and I must confess, that, though such a view would have hurt my palæontological feelings very much, I should not have been in a position to oppose it on very strong material grounds. Now, after Dr. Warth's discovery, it is impossible to make such a stand. The crystalline boulder series is proved to be of upper carboniferous age!

The rock-groups, which follow below are the (1) Pseudomorphic Salt-crystal Zone, (2) Magnesian sandstone, (3) Neobolus-beds. Of these the two latter are so intimately connected, that they can only be considered as forming subdivisions of one and the same horizon, and the first is of rather local occurrence, and has been formed under quite peculiar circumstances. Of the three the Neobolus-bed is the only one which is found to occur regularly over large tracts of country, the other two are more or less developed only locally, and must be taken as constituting only a local increase in thickness of the Neobolus-bed. This increase was brought about, as has been stated by me already on a former occasion, probably by the formation of dunes and back-waters at the mouth of a large river, which entered the sea in carboniferous times, coming from the south-east or south, somewhere in the region which is now occupied by the Eastern Salt-range.

If such was the case the three must be considered as forming one compact inseparable group. We can fairly say this group follows immediately below upper carboniferous beds, and must thus be of lower carboniferous age. I cannot see anything unreasonable in these deductions; and among all possibilities these seem to me again and again the most probable ones. The palæontological facts are decidedly in opposition

to the view of these beds being silurian, not a single species or even genus being identical; and the geological facts, without straining them in any way, can be interpreted so as to let these beds appear as of carboniferous age.

Thus, as long as no direct proofs can be adduced, that these beds are really older than carboniferous, I consider myself justified in retaining my view, expressed already a long time ago.

After all that has been said, the name "Productus-limestone" can now as well be applied to the whole series as in the beginning of the work. The term must now be considered as a synonym of "Carboniferous" in the widest sense, if one considers the Permian as nothing but a subdivision of the carboniferous, as Bunter Musche kalk is a subdivision of the Trias.

With this I take leave of the public in expressing the hope that it may fall to my lot later on to treat more in detail of the more recent fauna of the Salt-range.

PROF. DR. W. WAAGEN,
Oberbergrath.

Prague, May 1887.

SALT-RANGE FOSSILS.

Series XIII.

Vol. I.—PRODUCTUS-LIMESTONE FOSSILS.

Text.

With 32 Photozincographs.

Part	I		containing pages	1 to 72	published	23rd May 1879.
„	II		„	„ 73 to 183	„	4th June 1880.
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SALT-RANGE FOSSILS.

Series XIII.

Vol. I.—PRODUCTUS-LIMESTONE FOSSILS.

Plates.

Part I	containing	Platss	I to	VI	published	23rd May 1879
„ II	„	„	VII to	XVI	„	4th June 1880
„ III	„	„	XVII to	XXIV	„	28th Sept. 1881
„ IV	fas. 1 „	„	XXV to	XXVIII	„	22nd Dec. 1882
„ „	„ 2 „	„	XXIX to	XLIX	„	30th Aug. 1883
„ „	„ 3 „	„	L to	LVII	„	1st May 1884
„ „	„ 4 „	„	LVIII to	LXXXI	„	10th Dec. 1884
„ „	„ 5 „	„	LXXXII to	LXXXVI	„	2nd July 1885
„ V	„	„	LXXXVII to	XCVI	„	1st Oct. 1885
„ VI	„	„	XCVII to	CXVI	„	10th Dec. 1886
„ VII	„	„	CXVII to	CXXVIII	„	Feb. 1888

LIST OF PHOTOZINCOGRAPHS.

(In Text.)

Fig.			PAGE
	1. 2.	Uncinulus posterus, Waagen	428
	3.	Camerophoria humbletonensis, Howse	440
	4.	Camerophoria pinguis, Waagen	442
	5.	Spirigerella derbyi, Waagen	455
	6.	Spirigerella grandis, Waagen	463
	7.	Eumetria grandicosta, Waagen	488
	8.	Uncinella indica, Waagen	494
	9.	Martiniopsis inflata, Waagen	525
	10.	Surface sculpturing of Martiniopsis subpentagonalis, Waagen	527
	11.	Surface sculpturing of Martinia glabra	529
	12.	Reticularia indica, Waagen	543
	13.	Enteletes kayseri, Waagen	553
	14.	Enteletes lævissimus, Waagen	555
	15.	Streptorhyncus deltoideus, Waagen	585
	16.	Chonetes strophomenoides, Waagen	628
	17.	Chonetes compressa, Waagen	630
	18.	Strophalosia horrescens, Vern.	643
	19.	Strophalosia indica, Waagen	649
	20.	Chonetella nasuta, Waagen	657
	21.	Productus lineatus, Waagen	673
	22.	Productus semireticulatus, Mart.	680
	23.	Marginifera typica, Waagen	718
	24.	Richthofenia lawrenciana, Kon.	738
	25.	Hyolithes wynnei, Waagen	781
	26.	Michelinia abichi, Waagen & Wentzel	850
	27.	Michelinia placenta, Waagen & Wentzel	852
	28.	Schematic figures of intermural gemmation of a Monticuliporid; tangential sections	861
	29.	Schematic figures showing intermural gemmation of a Monticuliporid; longitudinal section	861
	30.	Schematic figures showing fissiparity as occurring in the Monticuliporids	862
	31.	Monotrypa mastoidea, Waagen & Wentzel	877
	32	Orbipora ambiensis, Waagen & Wentzel	879
	33.	Rhombopora obliqua, Waagen	964
	34.	Rhombopora polyporata, Waagen	965

ERRATA.

On page 964, immediately after the wood-cut, read Fig. 33 instead of Fig. 31.
On page 965, immediately after the wood-cut, read Fig. 34 instead of Fig. 32.

SALT-RANGE FOSSILS,

By WILLIAM WAAGEN, Ph.D.

I.—PRODUCTUS-LIMESTONE FOSSILS.

I.—PISCES—CEPHALOPODA.

INTRODUCTION.

The Salt-range is one of those parts of India which have already long since attracted the attention of palæontologists, on account of the great number of fossils which are known to exist there. In a country like India where marine deposits are the exception, and most localities exhibit only a series of beds more or less void of animal remains, the few exceptional places, like the central Himalaya, the Salt-range, Kachh or Trichinopoly, where remains of marine mollusks abound, are of double interest, as they alone can furnish a clue to a right understanding of the geological history of so large a tract of land as India is. It cannot be denied, that the Salt-range, on the whole, is not so rich in organic remains as is, for instance, the Trichinopoly district, but there is another factor which attaches even a greater interest to the Salt-range series from a geological point of view; this is, the representation there of a large number of different formations, which form a continuous series, and which thus represent together a by far more extensive period of the earth's history than is to be found united in any other country of India except in the north-western Himalaya. The geological evidence hitherto published as to the occurrence of such a series of formations has been tolerably completely recorded and discussed in Wynne's report[1]; the palæontological evidence, on the other hand, is much more scanty, and from a palæontological point of view, only four different formations had previously been fixed in the Salt-range: one palæozoic formation, containing several carboniferous species mixed up with a number of forms hitherto attributed to much younger formations; one jurassic formation, indicated solely by the description by Professor Oppel of *Bel. gerardi* and an *Ammonite* allied to *Stephanoceras macrocephalum* from Kálabágh; one nummulitic formation, from which d'Archiac and Haime described a number of

[1] Memoirs of the Geological Survey of India, Vol. XIV.

species; and a younger tertiary formation, as fixed by the description of fossil mammals by the late Dr. Falconer and recently by Mr. Lydekker. As this volume is designed only for the description of the fossils up to the base of the nummulitic formation, I have to treat here only of the older deposits, and for these the palæontological evidence showed previously only two formations, with a large break between them. Though by the present work this gap will be filled up to a great extent, yet it will be seen that the continuity of the series of formations, as proved by the geological investigations, is not so evident from palæontological facts, as many unfossiliferous beds intervene, which cause a break in the palæontological series. But even in the case where fossiliferous beds follow each other in perfect geological continuity, a very decided break in the forms is sometimes observable, whereby very distinct boundary lines between formations are marked off.

There are two principal boundary lines which will scarcely escape any observer travelling along the barren valleys of the range, and keeping his eyes open to the palæontological conditions of the strata of which the range is composed; they are the limit between the *Productus*-limestone and the ceratite beds, and that between the latter and the newer mesozoic formations. There are only very few genera crossing these limits and extending from the lower formation into the higher, and therefore the boundary lines between those formations mark large stages in the development of life in the country under consideration.

If we take a look at the table of formations as drawn up by Wynne in his report on the Salt-range[1], we find that he distinguishes a great number, ranging from lower silurian or cambrian up to the most recent deposits. There is certainly no harm in distinguishing all these formations, and the map can only gain in value by the delineation of so many sub-divisions; but there may be some question as to the general value of these divisions in comparison with the table of formations commonly adopted in science, and as to the propriety of treating these local divisions as real formations, equal in importance to "silurian, devonian," &c., used so extensively in European geology.

There is certainly no doubt that the presence or absence of fossils cannot be used as a criterion to mark off the boundaries between two formations; neither is the change in the lithological character of single beds of such a fundamental importance as to warrant the distinction of formations from this character alone; nor is the thickness of the beds, especially if they consist of sandstone or other clastic materials, at all a clue to the right understanding of the question of what ought to be considered as separate formations; and thus it is quite possible that several of Wynne's "formations" may simply be sub-divisions of one or the other "formation" as such are known to exist in Europe and elsewhere. The principal reason in favour of such a supposition would be, that the only criterion upon which the separation of formations within series of unfossiliferous rocks can be based, *viz.*, total unconformity at certain places, is absolutely wanting in the Salt-range.

[1] *l. c.*, p. 69.

This question, however, can only be solved by means of the organic remains in concert with the stratigraphical and lithological facts; and for the present, until the fossils shall have been worked out in detail, it will be practicable to establish three extensive series, which are well distinguished by the organic remains they include, and each of which will be treated of separately in the following work. These are: one lower series, the most conspicuous member of which palæontologically is the "Productus-limestone"; one middle series, not very thick, and little conspicuous in the general features of the range, but highly interesting from a palæontological point of view, entirely singular in its fossil fauna, and resting on the lower series without the intercalation of transitional beds; one upper series, very variable in its composition, never very rich in fossils, and very difficult to study. The top beds of this series pass without interruption into the nummulitic strata above, in such a manner, that it seems barely possible to indicate exactly the boundary between this latter formation and the older deposits.[1]

The series here adopted will include the following divisions of Wynne's table. Mem. G. S. I., vol. XIV, p. 69 :—

Upper series (Newer mesozoic formations).	10. Olive series	... Cretaceous	of Wynne.
	9. Variegated group ...	... Jurassic	
Middle series (Ceratite beds).	7. Ceratite beds	... Trias	
Lower series (Productus-limestone).	6. Lower limestone of Salt-range	... Carboniferous	
	5. Speckled sandstone ...	... ?	
	4. Magnesian sandstone ...	... ?	
	3. Obolus or Siphonotreta beds	... Silurian	
	2. Purple standstone ...	... ?	
	1. Saline series ...	... ?	

The two lowest divisions of Wynne's I do not include in my lower series, as they have hitherto been found perfectly void of organic remains.

The attention of the reader must, however, be called to a point which requires some caution: the parallelism of the large series, which have been distinguished at present by me for practical purposes, with Mr. Wynne's sub-divisions, is to be understood as correct in a general way; but in the detail of the sections published in Wynne's Memoir, the single beds as grouped under his headings are not always rightly placed, though the sections are partly my own. Owing to the unfortunate circumstance of my illness and absence, the Salt-range report had to be published independently, and some sections taken down and measured by me have been arranged by Mr. Wynne in a manner differing materially from the classification that I adopt.

I propose therefore to republish in the concluding chapters of this work my sections as I have taken them down in the field, and then to draw from them the

[1] Among the uppermost beds composing this series, there occur the beds containing *Terebr. (Waldheimia) flemingi*, Dav., which had been considered by Fleming and Wynne carboniferous, but which were already suspected by Davidson to be newer, a view confirmed afterwards on the ground, and pointed out to Mr. Wynne by me.

conclusions as to the development of the several formations at different localities in the Salt-range.

From what I have said on the foregoing pages, it will appear that this work on the Salt-range fossils can very conveniently be divided into several parts, if we take the natural boundaries of the faunas in time as the base for such a division; and in this manner the work will gain in practical value for the geologist, for whom it is designed in the first place. I therefore propose to divide the present work into four parts, which I shall designate as follows:—

Part I. Fossils from the Productus-limestone.
„ II. Fossils from the Ceratite beds.
„ III. Fossils from the Newer Mesozoic formations.
„ IV. General conclusions.

Before concluding these introductory notes, one pleasant duty is yet left to me, to express my most sincere thanks to all the scientific bodies and men of science who have aided me in undertaking the present work.

First, and above all, I have to offer my most sincere gratitude to His Excellency Lord Lytton, who of his own accord, with his well-known interest for scientific and literary endeavours, turned his attention to the execution of this work, and through his kind influence I am now in a position to continue, without the disturbing anxieties of pecuniary wants, the labours I had begun in sorrow and difficulties. Before this arrangement had been effected, it was a great boon to me that some scientific bodies had taken an interest in the work, and in this respect I have to mention before all the Royal Society of London, who made me a grant of £50, and the London Geological Society, who awarded me the proceeds of the Lyell Geological Fund, and sent me all the materials from the Salt-range in their possession for comparison and description. Here in Vienna I owe the greatest thanks to the Imperial Geological Institute, whose Director, Hofrath Ritter von Hauer, put a separate room in the Geological Institute buildings at my disposal, as my special office, and for the safe keeping of the valuable materials in my hands; the Director General and officers of the Imperial Mineralogical Museum of Vienna aided me in many ways, by the loan of books and by furnishing me with materials for comparison.

But also many private gentlemen in England, Austria, Germany, France and Russia have given me their lively support by the communication of books, advice, and in many other ways. In this respect I mention in the first place with the utmost gratitude Dr. T. Oldham, who has passed away from us recently, but whose memory will live in science for ever for all that he has done during his long tenure of office in India to promote scientific enquiries in that country, and to aid every scientific endeavour to the utmost of his power. To me he has always been the truest of friends. Next to him I owe the greatest thanks to Mr. H. B. Medlicott, Dr. Oldham's successor, who not only procured the permission of Government to have the materials sent to me, but has also undertaken the unpleasant task of

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PART I.

FOSSILS FROM THE PRODUCTUS-LIMESTONE.

The lower series of rocks composing the Salt-range has been divided by Wynne in the following groups:—

Palæozoic.		Thickness.
6. Lower limestone of Salt-range (Carboniferous.) ...	Gray and magnesian limestone, calcareous sandstone and argillaceous beds, numerous *Producti, Spiriferi, Bellerophontes, Goniatites* and many other fossils	Feet. 300 to 500
5. Speckled sandstone	Speckled reddish and white sandstone, red and lavender clay	250 to 450
4. Magnesian sandstone	Light-coloured magnesian sandstone, dolomite-sandstone and shales	150 to 250
3. *Obolus* or *Siphonotreta* beds (Silurian.) ...	Black shales with glauconitic calcareous layers and sandy bands, *Obolus* or *Siphonotreta* ...	30 to 150
2. Purple sandstone	Deep purple sandstones	250 to 450
Diorite (?) and ash (Eruptive.)	A few exposures connected with the salt-marl close up to base of No. 2	Lenticular.
1. Saline series	Bright scarlet gypseous marls, with thick beds of rock-salt, gypsum, thin dolomitic layers ...	800 to 1,500 Total unknown.

As appears from this table, Wynne considered the different divisions distinguished as equivalent to the formations from silurian to carboniferous, that is to say, as equivalent to the whole palæozoic series, as it has been defined in Europe and elsewhere. In thus assigning an age to his sub-divisions, he relies chiefly on the organic remains; but it still remains to be demonstrated, whether the organic remains justify such a homotaxis, and that will only be apparent at the close of the present work.

The deposit, which gives most promise of a definitive solution of this question, is the "Productus-limestone," as it abounds in organic remains, and we must start from this member of the series if we want to ascertain how far the preceding deposits might be considered rightly as separate formations.

It has been one of the chief objects of my investigations in the Salt-range to settle the questions about the vertical range of the single fossil species, as this alone

might furnish data for the right understanding of the value of the single divisions, and for this sole purpose I have measured those detailed sections published by Wynne, and have collected the contents of each single bed separately. I therefore am in a position to indicate the exact geological horizon of each single specimen collected by me, and I can vouch for every indication in this direction in the following work.

If we study with some attention the sections published in Wynne's report, it is not very difficult to come to the conclusion, that within that division of rocks called by Wynne and previous writers "carboniferous," and which I designate for the present as "Productus-limestone," three groups can easily be distinguished as conspicuous in most sections, but which are not all three developed everywhere. If we begin at the western end of the range and proceed towards the east, we find the first traces of Productus-limestone in the Lún valley, west of the Indus, where a huge mass of limestone, accompanied by a bed of conglomerate, sticks out in a vertical position in the middle of the valley. Fossils are very scarce in this limestone, and thus its exact position within the series could not be ascertained.

Regular sections through the different beds composing the Productus-limestone are first observed about Khyrabad, and from this point towards the east I have measured many sections as far as the Nílwán, to the east of which the fossiliferous beds of the group have disappeared. The best and most extensive sections are to be met with in that part of the range called by Wynne the "Son Plateau," and in these sections everywhere the three sub-divisions of the Productus-limestone are easily observed: a brownish-yellow sandy calcareous, partly dolomitic series, about 100 to 200 feet in thickness, often, however, very much less, forming the upper sub-division; a light gray thoroughly calcareous series, mostly limestones in very thick beds, partly silicious, and as much as 400 feet in thickness, forming the middle sub-division; and lastly a sandy, light gray or dark carbonaceous series, never very thick, forming the lower sub-division. Further eastwards, however, the upper sub-division already disappears a short distance east of Khund-ghât; the last traces of the middle division are met with to the north of Katta; and in the Nílwán ravine the last remnants of the fossiliferous beds of the lower division are lost among the sandstones which have been designated by Wynne as the "speckled sandstone group."

Even in the most typical sections the lower boundary of the Productus-limestone is by no means beyond doubt. There exists a perfect transition from the fossiliferous sandstones to the unfossiliferous lavender clays; the whole lower sub-division is locally sometimes replaced by unfossiliferous sandstone, and lavender clays appear sometimes above the fossiliferous beds, thus unquestionably indicating the close connection in which the "speckled sandstone group" stands to the lower sub-division of the Productus-limestone. If we therefore wish to retain Wynne's group No. 5, it will be by far more natural to class the lower sub-division of the Productus limestone with this speckled sandstone group, and to draw the boundary line

between groups Nos. 5 and 6 at the base of the compact limestone, the latter being the most conspicuous member of group No. 6. It seems therefore more than likely that Wynne's "speckled sandstone group" is not to be considered as a separate formation, but forms only a sub-division of the same formation to which the "Productus-limestone" belongs. Very likely the same fate is in store for his "Magnesian sandstone," which in its western extension is so closely connected with group No. 5 that a separation seems barely practicable, although such separation is very markedly drawn in the diagrammatic section figured in Plate IX, p. 69. It is only further towards the east that this group attains any distinctive characters, which justify its separation on petrological grounds as a conspicuous member of the series of rocks exposed in the Salt-range. But this alone is barely sufficient to separate the group as a distinct formation from the rocks to the west, which seem more or less to pass horizontally into the magnesian sandstone.

The next lower member in the series, the "Obolus" beds of Wynne, is again so closely connected with the one above it, that even Wynne admits that they might be treated as members of one and the same formation.

A by far more marked break in the continuity of the rocks, than has been indicated by any of the boundary lines down to the division last mentioned, exists between this latter and the "Purple sandstone" of Wynne. This purple sandstone and the "Saline series" together may rightly be placed in opposition to all the overlying strata, from the "Productus-limestone" downwards.

There can be but little doubt that the "Purple sandstone" must be considered only as a sub-division of the same formation to which the "Saline series" belongs; and thus, following up the clue afforded by the stratigraphical relations, we are enabled to divide the palæozoic rocks of the Salt-range into two series, about equal in importance, and even about equal in thickness, as, according to Wynne's indications, the upper one ranges from 730 to 1,350 feet, the lower one (so far as exposed) from 1,050 to 1,950 feet, in thickness.

Only the upper of the two series is fossiliferous, and the species contained therein will be treated of on the following pages. I may be justified, from what has been said, in including all the beds from group No. 6 down to No. 3 under a common heading, for which I have chosen the most conspicouus member of the whole series, the Productus-limestone. Of sub-divisions or groups within this series I shall retain and use in the description of the fossils the following:—

1. Upper Productus-limestone.
2. Middle Productus-limestone.
3. Lower Productus-limestone and speckled sandstone.
4. Magnesian sandstone.
5. Dark shaly beds below the Magnesian sandstone.

How far these sub-divisions may correspond to one or several of the formations as they have been distinguished in Europe, will only be apparent at the end of this work.

DESCRIPTION OF FOSSILS.

Sub-Kingdom: **VERTEBRATA.**

Class: PISCES.

Sub-Class: PALÆICHTHYES.

Order: GANOIDEI.

Family: *SAUROIDII.*

Genus: SIGMODUS, Waagen.

There is one single tooth preserved among the materials from the Salt-range which has puzzled me very much, and the determination of which is even now not very satisfactory. The tooth is figured Pl. I, fig. 7, and from its general appearance, if it had been found in mesozoic strata, nobody, I think, would have hesitated to attribute it to some large Saurian Reptile. The case is, however, different here, as the fossil has been discovered in undoubtedly palæozoic deposits, and thus the general appearance must be distrusted, and upon closer examination some characters are detected which seem to point to the supposition that this tooth is not a Reptile's, but that of a Fish.

If we look up the remains of Ganoid fishes (the teeth of the *Selachii* or *Dipnoi* are out of the question) which have been hitherto described, the three genera which bear most resemblance to the fossil under consideration are: *Cricodus* and *Lamnodus*, Agassiz, from the Old-red-sandstone, and *Centrodus*, McCoy, from the carboniferous limestone. All three have in the first place a simple, undivided pulp cavity; besides this, the first bears many longitudinal ridges, the second has a more or less cutting edge with sharp lateral ridges and many intermediate ones near the base; the third has none at all; the first two have got no distinct enamel layer, the third has. If we compare now our tooth with these three, we find that it is clearly distinct, specifically and generically, from them, and thus we must consider our fossil as belonging to a new genus, which we may define in the following manner:

Tooth large, somewhat sigmoidal, with a tolerably large pulp cavity. Surface smooth, only in some places a fine striation visible with the lens, two sharp lateral ridges extend from the apex down to the middle of the tooth. A distinct enamel layer absent or very thin, except possibly along the lateral ridges, which are somewhat transparent. The genus is distinguished from *Cricodus* by the absence of many longitudinal ridges, from *Lamnodus* by the want of those ridges near the base, and from *Centrodus* by the absence of a distinct enamel layer, by the smaller pulp cavity, and the two lateral ridges.

The dimensions of the tooth are so very large, that it must be supposed to be a laniary tooth, and that the fish, like *Rhizodus*, possessed some of these in each jaw, interposed between many smaller teeth of common size.

Though the general appearance of the tooth in question may tend to show that it came from some Saurian Reptile, yet the nearly entire absence of a distinct enamel layer covering the surface of the tooth goes far to prove that it was to a fish that this tooth originally belonged.

1.—Sigmodus dubius, Waagen, n. sp. Pl. I, fig. 7.

The general form of the single tooth which exists of this species is elongately conoidal, gradually tapering towards the apex, which in the specimen is not sharply pointed, but slightly worn or broken off. It is curved backwards below, and again slightly in front at the apex, so as to give the tooth a slightly sigmoidal curvature. The whole surface is covered with a shining layer of ganoine, which shows in certain places under the lens a fine longitudinal striation. Towards the apex there appears on each side of the tooth a sharp ridge, which commences a little below the middle of the tooth and is most developed near the apex. The pulp cavity is not very large, only reaching about halfway up the tooth, forming a somewhat eccentric cone. The section of the tooth is not entirely round, but somewhat compressed from front to back, so as to cause the lateral parts of the tooth to project further.

As there was only one specimen at disposal, it was not possible to make a microscopical section across the whole tooth; and only splinters taken off from different parts of the fossil could be used for that purpose; but even these were sufficient to show that the structure of the tooth was very simple. The transverse section (Pl. I, fig. 7*e*, magnified 240 times) exhibits very numerous dentine tubes closely packed together, radiating in straight lines from the centre of the tooth; in the longitudinal section (Pl. I, fig. 7*f*, also magnified 240 times) those dentine tubes also are visible; they pass very slightly undulating from the centre of the tooth towards the surface, in a somewhat ascending way, and reach near the surface a clear transparent layer, at which they are suddenly turned up, forming thus very likely minute calcigerous cells. The clear layer must probably be considered as consisting of ganoine, it includes a great number of black bodies, which might be hollows (calcigerous cells ?), or might also be a product of fossilization. Beyond this layer there seems to be in some places also a very slight indication of a thin coating of glassy enamel, which is, however, nowhere sufficiently distinct.

The dimensions of the tooth are as follows:—

Length of the tooth (about 2 mm. at apex being broken off)	30 mm.
„ of the pulp cavity about	14
Thickness at base from front to back	11
„ at base from side to side	13 ?
„ a little below the apex of pulp cavity from front to back	8
„ „ „ „ from side to side	10
„ 7 mm. below the apex from front to back	4
„ „ „ from side to side	5·5

Locality and geological position.—On page 145 of his report, Wynne mentions some small broken fish teeth out of the magnesian sandstone of Chel hill (eastern Salt-range). These are the only organic remains which have been detected in the course of the survey in this particular division of rocks, and it is, therefore, of great importance to state anything in connection with them. When I was looking for the first time through the collection of Salt-range fossils, I paid particular attention to these teeth, and found after some search a piece of a dark sandstone which contained apparently a small pointed tooth in a rather unsatisfactory state of preservation, a label of blue paper attached to it calling particular attention to this piece, as being of special interest. It came from the magnesian sandstone of Chel hill. In examining the specimen more closely, I found that the apparently small fish tooth was only the upper portion of a large tooth which was entirely covered up by the rock, and in following up the fossil I succeeded at last with great care and labour to set free from the adhering rock the whole tooth above described. Thus, I think, there cannot be any doubt that the tooth just described under the designation of *Sigmodus dubius* is one and the same as the small fish tooth mentioned by Mr. Wynne. On the other hand, it is only natural that Mr. Wynne, in subsequently going through the Salt-range fossils, did not recognise again his specimen in the entirely changed condition in which he found it; this may probably account for his attaching a new ticket to the specimen, stating that there must have been a miscarriage of labels. After the foregoing statement, however, of the facts, there can remain, I think, no doubt, that this tooth is in reality the one which was found by Mr. Wynne in the magnesian sandstone (group No. 4 of my table, p. 8) of Chel hill.

Remarks.—This remarkable tooth is so far different from all the fish teeth hitherto described that it seems not to be necessary to give any distinctive characters. It would be far more difficult to distinguish it from the teeth of some mesozoic Saurian Reptiles. Only the absence or excessive thinness of the covering enamel layer seems to indicate a fundamental difference.

Order: DIPNOI.

Family: *COCHLIODONTIDÆ.*

Genus: POECILODUS, Agassiz.

It is not without doubt that I introduce this genus here, as the tooth which I have to describe, though showing many characters of *Poecilodus*, yet is somewhat extreme in their development, and thus might possibly better be considered as a separate genus. However, the single tooth which has been obtained seems not sufficient to found a new genus upon, and thus it is better to retain this form in the old genus.

The position of the genus in the order *Dipnoi* seems not to be beyond doubt, but its general relations seem to point in this direction, and thus I have placed it here.[1]

1. Pœcilodus paradoxus, Waagen, n. sp. Pl. I, fig. 1.

The general form of the single tooth we possess of this species is elongate, rectangular, with parallel sides, the upper surface in appearance very different from the lower. The whole length of the tooth is not preserved, and there is no means of knowing how long it may have been.

The surface, which I consider to be the lower one, is smooth, moderately rounded, with slight depressions along both margins. At the well preserved end there is a conical protuberance, which has, however, been broken off in cleaning the tooth from the adhering rock, but which is indicated in fig. 1 *c* by a dotted line. The whole surface is finely punctured.

The other surface shows the characteristic sculpture of *Pœcilodus* in a very exaggerated manner. There are several high, thick, step-like ridges crossing the tooth in an oblique direction. They are low and sharp, and form an arch on the unbroken margin of the tooth, but become gradually higher towards the middle of its length. The crest of these ridges is very unequal in height, and from this they appear somewhat coarsely serrated. In the depths of the furrows, which separate the ridges, there are slight grooves, arranged in a row along each furrow. The surface of the ridges is also punctured.

The most remarkable feature of the tooth is its internal structure. In its middle there is an elongated body of calcigerous cells, very irregularly distributed. This is circumscribed all round towards the surface by a row of larger cells, which are heaped together, and thus form a very distinct line of separation towards the outer layer of the tooth. This outer layer consists all round of very numerous dentine tubes, which originate from the cells and terminate on the surface, causing the punctured appearance of the latter as mentioned above. The outer layer is very thin in the grooves between the ridges on the upper surface, but very thick on the lower, and thus I am quite at a loss to say which of the two surfaces of the tooth has been the side of the crown and which the side of the root. I have placed the tooth in the figures as *Pœcilodi* are generally placed, but I cannot tell if this position is right, and if it should not be reversed.

The dimensions of the specimen are as follows:—

	mm.
Length of the tooth from preserved margin to the fracture	28
Breadth of the tooth at preserved end	20
„ „ „ at fracture	19
Height of the tooth in the middle	9·5

[1] Prof. Huxley's paper in the Decades of the Geological Survey of Great Britain has been inaccessible to me, as no copy of the "Decades" exists in Vienna.

Locality and geological position.—The single specimen which is contained in the collection was found by me at Virgal, in a coral limestone, in the upper region of group No. 2.

Remarks.—There is no other species of *Pœcilodus* to which our tooth could possibly be compared except *Pœc. jonesi*, Ag., or *P. foveolatus*, McCoy, of the carboniferous limestone of Armagh. However, both the species mentioned have the projecting ridges on the surface much more obliquely arranged, and are thus easily distinguishable. In this respect *P. paradoxus* resembles even more a *Elimaxodus* than a *Pœcilodus*.

Order: SELACHII.

Family: *CESTRACIONTES.*

Genus: HELODOPSIS, Waagen, n. g.

This genus in its general appearance very much resembles *Helodus*, which genus has been established by Agassiz for teeth of which the enamelled portion is more or less elongated, and bears in the middle a conical protuberance. The teeth of the genus here proposed differ, however, in several important points from this diagnosis, and may be described as follows:—

Teeth in several rows in both jaws, each tooth transversely elongated, more or less rectangular, and consisting of two very distinct portions, one hard, shining, enamelled portion, the crown, and one osseous portion, the root.

The crown is more or less saddle-shaped, with a slight depression in the middle, a very slight elevation on the external margin of the tooth, and a very strong broadly elevated part on the inner margin. The external part of the tooth is often very short, and then the whole tooth seems to consist only of a broadly rounded elongated callosity, surrounded on its external side by a flattened margin. The whole surface of the crown is covered by a fine punctation, as is the case in all *Psammodontidæ*, caused by the termination on the surface of the very numerous dentine tubes which traverse the substance of the crown in a radiating direction.

The root is about as large as the crown portion of the tooth, but is not often well preserved, and there is only one specimen in which it is nearly entire. From this specimen it is apparent, that the root does not lie vertically under the crown, but is inclined backwards, so as to project largely from under the crown on the posterior margin of the tooth; whilst on the anterior margin a part of the crown projects largely above the retracted part of the root. There is created thus on the anterior margin of the tooth a deep hollow, in which a number of transverse grooves can be observed, separated by low, somewhat irregular ridges. On the projecting back part of the root, on the contrary, there are ten or more high elevated transverse ridges, separated by deep furrows, commencing at the margin of the crown and terminating at the posterior margin of the root.

From these peculiarities it becomes apparent that in each jaw stood several teeth, or several rows of teeth, articulating with each other by their roots in such a manner that the projecting parts of the roots of each row of teeth fitted into the grooves of the next row behind, the teeth thus covering each other partly like the scales of a fish.

From this description it may easily be gathered, that the genus under consideration differs from the old genus *Helodus* in several important points, the most conspicuous of which is perhaps that the highest part of the tooth is not in the middle of the crown, but at the internal margin, and that the root is of a quite peculiar form.

Other genera are still far less allied to the teeth just described.

1. Helodopsis elongata, Waagen, n. sp. Pl. I, figs. 3, 4.

This species is not very rare in the Productus-limestone of the Salt-range, and though the single teeth vary greatly as to size, yet in their general form they are all much alike.

The general form of the teeth is somewhat trapezoidal, with a high elongated callosity placed transversely upon the tooth on the inner margin, and with a narrower flattened external part, again slightly elevated towards the external margin in some of the smaller specimens. This flattened part is about equal in length to the breadth of the callosity.

The anterior and posterior margins converge towards the outer end of the tooth, and thus the tooth seen from above is broadest at the elevated callous inner extremity and tapering gradually thence towards the outer flatter end.

The whole surface of the crown, which is very sharply defined towards the root, is covered by a fine punctation.

The root part in all the specimens of this species is more or less broken away; in most of them, however, the deep hollow is still observable, which was destined to contain the projecting ribbed part of the root of the tooth next in front, and which extends below the anterior margin of the crown.

The dimensions of two specimens are as follows:—

	I. mm.	II. mm.
Entire length of tooth	19	16
Breadth of tooth at the callous inner end	20	13
„ „ at the flattened outer end	13·5	9
Height of tooth at the inner callosity	11	6
„ „ at the outer end	6	6
„ „ in the middle	6	4·5

The measurements here given do not, however, indicate the maximum size the teeth can attain. There are fragments in the collection, consisting only of part of the callous extremity and measuring from back to front about 30 mm. in diameter, indicating thus a tooth of about that length.

Locality and geological position.—There are altogether four teeth of this species in the Salt-range collection, two of which are tolerably well preserved. One of them was collected by Mr. Wynne at Khund Ghát together with a great many other fossils in the beds of group No. 1 (see p. 8); another specimen was found by myself west of Khúra (Khoora) at the base of the same group; two fragmentary specimens were collected by me at Jabi, in the same bed with the Cephalopoda formerly described by me from that locality. From this it appears that the species is restricted to the upper division of the Productus-limestone, or to group No. 1 of the list of sub-divisions (see p. 8).

Remarks.—This species can only be compared to some specimens of *Helodus planus*, Ag., which, however, are never as inflated as the Salt-range specimens, and never have so developed a root; the latter peculiarity distinguishes *Helodopsis elongata* from all the species of *Helodus*.

A species which also bears some resemblance to the one just described is *Psammodus angustus*, Promanowsky, and indeed, from its general form, it appears most likely that this must be considered as a *Helodopsis*. From *H. elongata* it can be distinguished by the narrower and more regularly rectangular form of the teeth. *Psammodus angustus* was described originally from the upper carboniferous limestone of Miatchkowa near Moscow.

2. Helodopsis abbreviata, Waagen, n. sp. Pl. I, fig. 6.

There is a tooth preserved in the collection of Salt-range fossils which indicates a second species of *Helodopsis*, and which I describe under the above name.

The general form of the tooth is approximately square, with a broadly rounded, thick, elevated part, covering nearly the whole space of the square, and a narrow flattened margin at the external extremity. Besides this general form, the crown of the tooth shows a very fine punctation, and is very sharply defined from the root part of the tooth, which is very well preserved in this specimen.

The root, as mentioned in the description of the genus, is shifted backwards, so as to project behind from under the crown some millimeters, this part of it being covered on its upper surface by high angular vertical ridges, which are separated from each other by deep furrows commencing at the margin of the crown and terminating at the posterior margin of the root. Corresponding to this projecting posterior part of the root, there is on the front part of the tooth a deep hollow, also covered by ridges, which are, however, less high than those on the posterior part. The furrows which separate the narrow ridges are broader, and the whole arrangement of them is as if made from an impression taken from the projecting posterior part of the root.

The internal structure of the tooth, as exposed in a fracture by which a part of the elevated callosity is broken off, shows closely arranged dentine tubes travers-

ing the crown in a radiating direction, causing the fine punctation on the surface of it, and a porous spongy texture of the root.

The dimensions of the single tooth in the collection are as follows:—

	mm.
Entire length of tooth (approximately) 13 to 14 mm., of which are preserved	11
Breadth of tooth at internal extremity	14
„ „ „ at external extremity	11
Height of tooth on the elevated part	7
„ „ „ on the flattened external part	5·5

Locality and Geological Position.—The single specimen existing of this species was collected by me in the Nílwán ravine, in the lowest beds of the fossiliferous lower strata of the Productus-limestone (bed No. 11 of my section), and must thus be attributed to division No. 3 (p. 8).

Remarks.—The species here described is easily distinguishable from the foregoing species, *Helodopsis elongata*, by the nearly square form of the tooth, and the broadness of the callosity at the inner margin as well as the small development of the flattened external part.

Genus: PSAMMODUS, Agassiz.

This genus is very poorly represented among the Salt-range fossils, but as traces of it have been detected among the materials in my hands they must be mentioned.

1. Psammodus, sp. indet.

There is a single fragment of a tooth of *Psammodus* in the collection of Salt-range fossils, which, however, allows of no doubt as to its generic position. The fragment consists of a piece of the crown, the root being quite broken off. The surface is perfectly smooth, covered by numerous fine pores, as in *Psammodus porosus*, Ag.; the internal structure shows numerous dentine tubes radiating towards the surface as in other *Psammodi*. The fragment seems to indicate a tooth of a rather arched surface; but of the general outline of this tooth nothing definite can be ascertained.

Locality and Geological Position.—The fragment was collected by myself at Káfir-kot on the Indus, in the beds of compact limestone composing the middle region of the Productus-limestone, and forming group No. 2 of the series (p. 8).

Family: *PETALODONTIDÆ.*

Genus: PETALORHYNCHUS, Agassiz.

This genus is represented among the Salt-range fossils by a single tooth, which is not even in a good state of preservation, but yet it is sufficient to determine with every possible certainty the genus as well as the species.

1. PETALORHYNCHUS INDICUS, Waagen, n. sp. Plate I, fig. 8.

The general form of the single tooth in our possession is oval, higher than broad, convex on the outer, concave on the inner side. The whole extent of the outer or convex side of the tooth is finely granulated, except the upper or crown part, which is very much worn down by use, and presents in the middle a trapezoidal smooth surface, and on both sides triangular parts bearing a fine radiating striation. From the lower end of the smooth middle part of the crown extend two low slightly divergent ridges across the whole outer surface of the root end of the tooth. The upper sharp cutting end of the crown has been broken away, and also the root is defective all round. The natural margin of the tooth has been preserved only on both sides, where for a short distance it can be observed.

The original length of the tooth may have been 19 mm., of which, however, only 15 mm. are preserved.

The structure of the tooth is very well seen at the broken edges; and it appears that the crown part shows the same numerous radiating dentine tubes, which can be observed also in the *Psammodontidæ*, etc.; but the root part has got a very compact texture, and no such tubes can be observed there with the lens. I had, however, no opportunity to make a microscopical section of any part of this tooth, on account of the insufficiency of the existing material, and thus the minor features of the structure of it are unknown to me.

The dimensions of the tooth, as far as they can be measured, are as follows:—

	mm.
Whole length of existing fragment (upper and lower ends being broken off)	14·5
Entire breadth of the tooth	15·0
Height of the crown part so far as preserved	4·0
„ root part „ „	12·0
Greatest thickness of the tooth	3·0

Locality and Geological Position.—The only specimen existing of this species was collected by me at Chidru, in the uppermost division of the Productus limestone, group No. 1 of the list (p. 8).

Remarks.—The position of the species just described, in the genus *Petalorhynchus*, seems to require some remarks. The principal distinction between the genera *Petalodus* and *Petalorhynchus* seems to be, that in the former the crown, on the whole, is transversely oval, broader than high, and the root, or that part of the

tooth which is covered up by the following one behind, is not much longer than the crown; whilst in the latter the crown is generally more pointed, and only one-third or one-half as long as the root. Now, though the cutting margin of the crown is broken off in the tooth here described, and thus the form of that part cannot be ascertained, yet it can easily be seen, that the crown occupied only about one-third of the entire length of the tooth, and from this it seems probable that this tooth must be placed in the genus *Petalorhynchus*.

As to species, it is not difficult to distinguish this one from all the others as yet described. Though there have been figured a great many species by St. John and Worthen from the coal-measures of Illinois, yet there is none among them which can be compared with our species. More similar appears to be *Petalorhynchus sagittatus*, McCoy, from the carboniferous limestone of Armagh, especially the specimen fig. 2 bears some resemblance, but this seems to be due also more to the state of preservation of the specimen, it being also an old much worn tooth, than to a specific resemblance. The Indian species can always be easily distinguished by its much broader form in comparison to its length.

ICHTHYODORULITHES.]

Genus: XYSTRACANTHUS, Leidy.

It is a well known fact that nothing can be more difficult and less reliable than the determination of small fragments of the fin-rays of sharks, when the basal portion, the one inserted in the flesh, is wanting, and nothing remains but a small part of the upper portion without upper or lower end. Nevertheless, these bodies are of sufficient interest to mention even small fragments, if better materials are not procurable, but then the determination of them must be taken for what it is worth, and much stress must not be laid upon the name.

In the present case there are three small fragments of fin-rays before me, which can be determined only by the peculiarities of the ornamentation they offer, and in this respect no genus can be compared but *Xystracanthus*, Leidy. As in *Xystr. acinaciformis*, St J. and W., the tubercles covering the surface of the ray in longitudinal rows are smooth, with a shining surface, and on the anterior margin there are four rows of larger tubercles in an alternating position, as in *Xystr. mirabilis*, St. J. and W. Thus it appears to be safest to refer these fragments to Leidy's genus, which was described originally from the upper coal-measures of Kansas.

As to species I am able to distinguish two among the fragments at my disposal, one large, coarsely and sparingly ornamented, and one much smaller, covered by a very fine and close granulation.

These spines were found in company with the teeth of *Helodopsis*, and I am therefore inclined to consider both as of the same derivation. There is, however, no proof for such an assertion.

1. XYSTRACANTHUS GRACILIS, Waagen, n. sp. Pl. I, figs. 2 & 5.

General form of spine unknown, as only two fragments of the species have been found. Section very compressed, sagittate, pulp-cavity slightly indicated, but nearly quite broken away. Sides flatly rounded; anterior margin obtuse with two rows of vertically elongated large tubercles, one row on each side of the middle line, the tubercles alternating, smooth, shining, slightly constricted at base. Next behind those two anterior rows comes on each side a row of round, medium-sized tubercles. They are smooth like the others, shining like a string of pearls, and also constricted at their base. These are followed by numerous, closely arranged rows of alternating little smooth tubercles, which are smallest on the middle of the side and increase again slightly in size towards the posterior margin.

This is all that can be observed on the larger of the two fragments. The other fragment shows only some of the smaller rows of tubercles, and furnishes only proofs that the tubercles again increase in size towards the posterior margin, without ever attaining the size of those near the anterior margin. The posterior margin of the spine, preserved for a short distance on the smaller fragment, seems to be smooth.

Locality and Geological Position.—The larger of the two fragments (Pl. I, fig. 2) was collected by me at Virgal, in the top beds of the compact Productus limestone belonging to group No. 2 of the list (p. 8). The smaller fragment was collected by Mr. Wynne at Khund Ghât, together with *Helodopsis elongata*, in the beds of group No. 1.

Remarks.—Though the fragments of this species give a very imperfect knowledge of it, yet all that can be seen is so peculiar that a new species can safely be established. Altogether there are up to the present only four species of *Xystracanthus* known, and from three of them our species can be easily distinguished by its smooth tubercles; the fourth (*Xystr. acinaciformis*) has got smooth tubercles, but only a single row of them on the anterior margin, and thus our species seems also distinct from this one by the two alternating rows of tubercles which it bears on this margin.

All the species of *Xystracanthus* hitherto described have been found in the upper coal-measures of America.

2. XYSTRACANTHUS MAJOR, Waagen, n. sp. Pl. II, fig. 9.

A small fragment of a very large fin-ray has been sent to me out of the old collection at Calcutta, which represents a species of *Xystracanthus* distinct from the one just described, and which I designate under the above name.

The general form of the entire ray can be as little ascertained in this species as in the foregoing one, but the fragment is sufficiently large to show that the whole ray was reversedly curved, that is to say, that the anterior margin

presented a concave instead of a convex outline, quite the same as is the case in the other species of *Xystracanthus*. The sides are slightly convex, perhaps a little more so than in *Xystr. gracilis*, forming a sharp edge on the anterior margin. On both sides of this sharp edge large smooth elongated tubercles are situated at rather irregular distances, forming two longitudinal rows. These are followed by other irregular rows of tubercles, gradually diminishing in size as they are more and more distant from the anterior margin. The greater number of the tubercles are worn off, but those remaining show that they have been very irregular in size and distribution. They all are smooth, without crest or ridges, and all are strongly constricted at their base. Where the tubercles are worn away, the surface of the sides is covered by low nodular ridges, which show under the lens a fine longitudinal striation.

The internal structure of the ray is cellular, the cells being very minute in the outer region and coarser towards the middle. There is no trace of the pulp-cavity preserved.

Locality and Geological Position.—The single fragment of this species which is preserved in the Salt-range collection was found at Músakhel; it is, however, unknown from which particular bed or group the specimen may have come. From its general manner of preservation, it seems to me likely that it was collected in the higher beds of the Productus-limestone, in group No. 1.

Remarks.—This species can be only compared with *Xystr. gracilis*, described above; but it can be easily distinguished from this latter species by its clumsier form, its more irregular and less close ornamentation, and the sharp edge on the anterior margin, which is absent in *Xystr. gracilis*. The tubercles are also much more constricted at their base in *Xystr. major* than in *Xystr. gracilis*, whereby also they much more easily fall off in the former than in the latter species.

Sub-kingdom: **ARTHROPODA.**

Class: CRUSTACEA.

Order: BRANCHIOPODA.

Sub-Order: OSTRACODA.

Family: *CYPRIDIDÆ.*

Genus: CYTHERE, Müller.

In cleaning the beautiful set of *Nautili* brought by Mr. Wynne from Khund Ghât, I detected, on one of the pieces chipped off, a specimen of an *Ostracod*, which has remained up to the present the only piece of a Crustacean observed among the Salt-range fossils. I do not doubt, that if carefully searched for on the spot, many of these small organisms would be found, but neither I nor Mr. Wynne had suffi-

cient time at our disposal to hunt for merely microscopical objects. On the different specimens of fossils now in hand for description, no other but this single specimen could be detected.

It is a fact worthy of notice, that all other Orders of the *Crustacea*, principally the *Trilobites*, are absolutely absent in the Salt-range strata.

The specimen I have now to describe is very indifferently preserved, and thus it can be determined only with approximate accuracy. The figure which seems best to agree in its general form with our fossil is *Cythere elongata*, Mnst., and thus I can only compare it with Münster's species.

1. Cythere *cf.* elongata, Münster. Pl. VII, fig. 1.

1830. *Cythere elongata*, Münster: Bronn's Jahrbuch f. Min. 1830, p. 65.
1850. *Cythere elongata* (Mnst.): Rupert Jones in King: Permian Fossils, p. 62, Pl. XVIII, fig. 5.

The general form of the fossil, which seems to represent the right valve of a carapace, is about that of a bean, both borders, the ventral as well as the dorsal, being slightly incurved, the incurvation is, however, stronger on the ventral than on the dorsal border. Both extremities are perfectly rounded.

The valve is convex and perfectly smooth.

Locality and Geological Position.—The piece of rock to which the specimen adheres was chipped off by me from a specimen of a *Nautilus* collected by Mr. Wynne in the upper division of the Productus-limestone at Khund Ghât.

Remarks.—*Cythere elongata* was originally described by Münster from the mountain limestone of Regnitzlosau. M. Rupert Jones has found another specimen in a magnesian limestone, probably permian. Thus the species seems to range from carboniferous into permian strata.

Sub-kingdom: **MOLLUSCA.**

Class: CEPHALOPODA.

Order: ?

Family: *AMMONITIDÆ.*

Genus: CYCLOLOBUS, Waagen, n. gen.

It is with very great doubt indeed that I introduce the present genus, but several considerations have led me, though very reluctantly, to the definition of it.

We may characterise the genus as follows: Shell spiral, smooth, with a small deep umbilicus; whorls numerous, somewhat compressed, with a broadly rounded external side, deeply embracing each other so as to envelope the preceding whorl,

nearly entirely covered on the sides with not very numerous contractions of the shell (varices), indicating very likely the remnants of old apertural margins. The form of these varices is somewhat falciform, with a strong bend towards the front in the middle of the sides of the whorl, and being bent considerably backwards towards the external margin, entirely disappearing on the siphonal side of the shell. The increase in height of the whorls is very slow.

The most characteristic part of the whole shell is the sutures, which from their position alone may be taken to indicate the generic distinction of the shell under consideration from all the other genera of *Ammonitidæ*. The first glance at the drawing, Plate I, fig. 9, will show how peculiar the position of the sutures is, as they form a strongly curved parabolical arch, the summit of which is situated next to the umbilical margin; whilst the longer branch of the arch descends towards the siphonal part of the shell, the shorter branch, with only a few small lobes on it, reaches the umbilical margin in a somewhat radial direction. The whole suture is composed of a great many lobes and saddles, which are largest near the siphonal part of the shell, and decrease slowly in size as they approach the umbilical region. The principal lobes, first and second lateral, are in no way distinct from the following auxiliary lobes, and can be recognised solely by their relative position and size. The siphonal lobe is broad and fan-shaped. From the peculiar position of the sutures some strange features are the result. Though on the sides of the whorls the sutures stand so close together that the most prominent points of the lobes touch nearly the saddles of the preceding suture, yet along the siphonal part of the shell the distance of the septa from each other is about equal to half the height of the whole whorl from the siphonal margin to the umbilicus. Further, the position of the single lobes is shifted with the increase of the shell in the following manner: the siphonal lobe touches with its most prominent fingers the lowest parts of the first and second lateral saddles of the preceding suture; the first lateral lobe touches the second lateral and first auxiliary saddles, and so on, a peculiarity which has up to the present not been observed in any shell belonging to the family of *Ammonitidæ*.

The siphon is not well observable, but seems to be very narrow; of the manner, however, in which it breaks through the septa, nothing can be seen.

In the only specimen of this genus which I have got for description, the body chamber has been broken away, and thus I am unable to state how long that part of the shell may have been, neither is it possible for me to state what form the apertural margin may have possessed, though the outline which is indicated by the course of the varices on the sides of the shells makes it probable that the apertural margin had about the form of those varices.

In the year 1872 I was of opinion that the affinities of the shell under consideration were more in the direction of the genus *Phylloceras* than any other of the *Ammonites*, as at that time also *Amm. jarbas*, Mnst., was counted with that genus, and thus the variety of forms then included in it was by far greater than it is now considered to contain. Dr. V. Mojsisovics has shown that my *Phylloceras oldhami*,

as well as *Amm. jarbas*, could not be considered any longer as belonging to that genus, but he placed my species in the genus *Arcestes*, whilst he created for *A. jarbas* a new genus *Megaphyllites*.

There is no doubt that the genus I have just characterised shows a certain affinity to *Arcestes*, Suess., and Mojsisovics was thus justified in putting the only species it as yet contains in that genus.

The genus *Arcestes* can easily be divided into three large groups, which very likely must be considered as having sprung from different roots, and which will possibly in the future have to be considered as composing different genera. The first group is composed of the *Tornati*, the "group of *Arcestes tornatus*" of Mojsisovics; the second group comprises the by far greatest number of the species of *Arcestes*, containing the groups of *Arc. extralabiatus*, Mojs., *Arc. sublabiatus*, Mojs., *Arc. bicarinatus*, Mnst., *Arc. colonus*, Mojs., *Arc. intuslabiatus*, Mojs., *Arc. galeoti*, and of *Arc. subumbilicatus*, Bronn; the third division of the genus contains only one group, that of *Arc. cymbiformis*, Wulfen.

Only the last of those three divisions can be compared with our genus. The general form of the shell is much alike; varices occur, but the most striking feature is the sutures, which form an arch with the apex turned towards the mouth of the shell like in *Cyclolobus*, though this character is much less developed in the triassic species. Beyond this, however, the resemblance ceases. The single lobes are much more ramified, and secondary lobes appear between the principal ones. The distance of the septa is about equal throughout their extension and not much larger on the siphonal part of the shell, as is the case in *Cyclolobus*, and the lobes of the succeeding septa are not shifted sideways as I have described it above.

That the two shells *Arcestes cymbiformis* and *Cyclolobus* are distinct is obvious, and as long as connecting links between the two are wanting, a generic distinction can barely be avoided. It is quite a different question whether the newer has not taken its origin from the older form, and it cannot be denied that there is some probability of this being so; up to the present, however, any proof of such an assertion is absolutely wanting. Now I think it more advisable to create a new generic designation for the palæozoic form, and run the risk of it being proved that it is in intimate connection with the triassic species and must be considered as belonging to the same genus, than to unite generically the palæozoic fossil, showing such peculiar features, with the triassic Ammonite, and thus to anticipate discoveries which can only be established in the future. On the other hand, if *Arc. cymbiformis* should be proved to be in close connection with *Cyclolobus*, this species would very likely have to be placed in my genus, and could not be retained in the genus *Arcestes*.

The only species of the genus which has been discovered up to the present has been found in the palæozoic strata of the Salt-range.

1. Cyclolobus oldhami, Waagen. Pl. I, fig. 9.

1872. *Phylloceras oldhami*, Waagen: Mem. Geol. Surv. of India, Vol. IX, p. 353, pl. I, fig. 1.
1873. *Arcestes oldhami* (Waagen) Mojsisovics: Gebirge um Hallstadt, I, p. 72.

The general form of the shell is somewhat flattened, lenticular, with a broadly rounded siphonal part. The umbilicus is small and deep, surrounded by perpendicular walls which unite with the external parts of the shell without forming a distinct umbilical edge. The inner whorls are almost entirely concealed by the last one, and only a narrow margin of them remains visible within the umbilicus. The involution of the whorls is very large, so much so that nearly two-thirds of the room within the last whorl are filled up by the preceding one. The shell thus increases very slowly both in diameter and in thickness.

On the flattened sides of the shell several contractions or varices can be observed, and on the last whorl of the specimen under consideration I count six of them. They begin at the umbilical margin, in about a radial direction, are then strongly bent backwards a little below the middle height of the whorl, and turned again a little towards the front near the siphonal part of the shell, where, however, they disappear almost entirely. I have only got the cast for description, and therefore I am unable to tell whether, when the shell is preserved, these varices will be visible or not.

The general arrangement of the lobes is as mentioned in the description of the genus. There are altogether fourteen lobes between the siphonal side and the umbilical margin, with one or two very small ones on the umbilical wall. The siphonal lobe, taken as a whole, is the largest of all; and, rightly considered, nearly the whole suture forms but one large siphonal lobe extending from the siphonal part of the shell down to the bend, where the direction of the suture becomes approximately radial, that is, down to the eighth lobe from the siphonal proper. The latter is fan-shaped, very broad, and extended at the lower ramified end, and rather narrow at its upper end, where the external saddles from both sides approach each other. The lower end shows three branches on each side, of which the outer two on each side are not strongly separated, whilst the inner ones are long and narrow, bordering a deep narrow siphonal indentation. The external saddle is narrow, only about half as broad as the siphonal lobe at its base, terminating with one undivided, roundish phyllum. The first lateral lobe is about as broad as the external saddle, terminating at its lower end in three unequal short branches, and being provided along both sides with several short little dentated branches, which are in about a rectangular position towards the axis of the lobe. The first lateral saddle is very similar to the external one, only narrower and shorter. The second lateral as well as the following two auxiliary lobes are very similar in shape to the first lateral, terminating in three more or less symmetrical branches. The third auxiliary lobe is the only one with two branches at its lower extremity. The next following auxiliary lobes have again three terminal branches, or are simply pointed as they near the umbilicus. The saddles from the second lateral down to the last auxiliary have all a monophyllic termination.

The measurements of the specimen I have got for description are as follows :—

	mm.
Diameter of the shell	107
„ of the umbilicus	16
Height of the last whorl from the umbilical suture	55
„ „ „ „ „ from the siphonal part of the preceding whorl	20
„ „ „ preceding whorl from the umbilical suture	38
„ „ „ „ „ from the siphonal part of the next whorl	14
Thickness of the last whorl	35
„ „ „ whorl before the last	23

Locality and geological position.—The only specimen of this species which has hitherto been found was collected by myself at Jabi. I have described this locality on a former occasion as follows: "The locality whence I extracted the fossils with my own hands out of the rock is near Jabi north of Shahpoor, on the southern slope of the Salt-range. The rocks at this locality are, however, not well adapted for tracing out an extensive section, because the ground is greatly broken up and faulted in every direction. Ascending the mountain range north of Jabi, by the road which leads round the well of the village, one finds, after having crossed a little plateau, a well bedded series of thin limestone bands, intercalated with shaly marls, the whole about 20 to 25 feet in thickness, and in the upper part of this series one calcareous band principally is rich in fossils. *Brachiopoda* occur plentifully in the whole series, but *Cephalopoda* are only found in this thin bed." I can add very little now to this description, as not much more can be said about the locality, and what has been said seems sufficiently clear and distinct to admit of no doubt. Nevertheless some doubt has been thrown recently on my discovery. Thus I read in Barrande's Système Silurien, Céphalopodes, Extrait du, Vol. II, Texte V, p. 240, the following passage :—

"Pour les Ammonides, suivant l' opinion jusqu 'ici généralement admise dans la science, les premières espèces ont apparu dans le Trias, abstraction faite d'une récente découverte par M. le Doct. Waagen dans les Indes et qui exige confirmation." I do not know how I have deserved this distrust of my observations, as I do not remember any case in which an observation I had once clearly and distinctly stated had been found afterwards to be untrustworthy. I can only affirm once more, that I extracted the specimen under consideration with my own hands out of the rock *in situ*, together with many palæozoic fossils, none of them having been found loose on the surface. Nobody at all acquainted with the rocks and formations in the Salt-range, glancing only for a moment at the specimen, could doubt its coming from the upper division of the Productus-limestone, as from its preservation alone it is evident that this is the only possible rock and formation where it could have come from.

Thus the only specimen of this species which has hitherto been found comes from division No. 1 of the classification of the Salt-range rocks as proposed by me in the Introduction.

Remarks.—There attaches no little interest to this species, as it is the oldest true *Ammonite* hitherto described; but though the occurrence of such forms could have barely been looked for in truly palæozoic strata, yet the isolation of the single form found by me, and the peculiarity of its features, make it difficult to draw all the conclusions as to the development of the Cephalopoda in time, which such a discovery seems to warrant. As the matter stands, we can only say, that the occurrence of *Cyclolobus oldhami* in palæozoic strata is a proof that ancestors of different groups of *Ammonites* are of very different geological age, and that all the *Ammonites* do not spring from one, but from very different roots. The branch to which *Cyclolobus oldhami* belongs is certainly very much older than those branches which take their rise from the genus which I shall describe next below; but so long as no more ample materials are at our disposal, any speculation as to what forms of *Ammonites* might be in genetic connection with our species, or as to what form of *Goniatite* might be the ancestor of *Cyclolobus*, is as fruitless, as all such assertions if not founded on direct observations of specimens are absolutely hypothetical.

Discoveries like that of a true *Ammonite* in palæozoic strata are singularly adapted to show how little we yet know of the real development of organic forms in time, and what ample materials in that direction a close examination of strata in distant countries will yet bring to light. But only with such materials at hand will it be possible to write in the end a developmental history of single classes, for instance, that of the Cephalopoda.

Genus: ARCESTES, Suess.

There are two *Ammonites* among the materials I collected in the Salt-range, which I cannot separate generically from Suess' genus, though on a first glance the form of the lobes in both specimens seems so far different from that occurring generally in the genus, that it requires some explanatory remarks as to the grounds on which these forms are united with the above genus.

It is a fact, which has been proved by so many and careful observations that the correctness of it cannot be doubted, that in the *Ammonites* the most general tendency of development is that to the greater complication of the sutures. Whatever group of *Ammonites* we may take for observation, we will find that the sutures are more complicated in the geologically newer species than in the older ones. This law holds good also for the genus *Arcestes*, as has been proved by Dr. v. Mojsisovics, though the changes he was able to observe were rather minute, only forms from a very short period of the earth's history having been accessible to him for observation.

Now, if we descend the scale of development, proceeding from newer to older forms, we can easily imagine that we at last reach a stage when the suture is

nothing but a variously curved line, as is the case in the former genus *Goniatites:* only the transitional forms, which would unite the extremes on both ends of the scale, have been but partly detected as yet, and thus the supposition, that such a continuity of development in the sutures exists, remains more or less hypothetical. Within narrower limits, however, we may safely say that forms with more complicated sutures, and those with more simple ones, can very well, if other characters do not interfere, belong to one and the same genus; as the complication of the sutures indicates only a distinction in degree, and not in kind. We will be so much the more entitled to say this, if there exist some transitional forms which bring the extremes nearer together. This is the case with the two species I shall have to describe on the following pages; they are linked to the more typical forms of the *Arcestidæ* by the species *Arcestes megaphyllus* of Beyrich, which has the sutures already considerably more complicated than my species. Thus we can say that in their general character the lobes of our species do not differ from those of *Arcestes*, except by their greater simplicity, as the arrangement of the single lobes and their relative development is identical with those of the genus mentioned.

It remains to consider whether the other characters of the species under consideration justify their union with *Arcestes*. Neither the length of the body chamber nor the form of the aperture can be observed, as both are broken away; the general form of the shell, however, agrees perfectly with the genus. The only difference I can observe rests in the siphon, which has its funnel passing through the septa, in one case apparently directed backwards, in the other towards the front. How little reliable, however, this character is, appears again from Abich's[1] specimen of *Goniatites striatus*, which has the funnel most distinctly directed towards the front.

We have thus, for the species under consideration, the general form of the shell and the general character of the sutures identical with the genus *Arcestes*. From what I have said, it appears, however, that these species represent transitional members between the older *Goniatites* and the newer forms of *Arcestes*.

It remains now to discuss how far they are connected with the *Goniatites*. There is but little doubt that most palæontologists would have considered these forms to belong to the genus *Goniatites*, on account of the simplicity of the saddles and the little ramification of the lobes, to which is added in one species the backward direction of the siphonal funnel. If we look through the forms of *Goniatites* hitherto described, we do not find any more closely allied to our species than those described by Verneuil, and later on by Karpinsky from the sandstone of Artinsk, of which chiefly *Gon. koninkianus*, *Gon. soboleskianus*, and *Gon. kingianus* seem to be near allies to the Salt-range forms. Nevertheless there exists a difference which seems so essential that I cannot in the least advocate to unite these species with Suess' genus, but am of opinion that between the Prussian fossils and our

[1] Abich: Geologische Forschungen in den Kaukasischen Ländern I, pl. XI, fig. 2.

species there exists a deep gap, which will only be filled up by future discoveries. If we consider the Salt-range species, we find that, as in all species of *Ammonites*, there can be easily distinguished three principal lobes, a siphonal and two lateral ones, of which the interior margin of the second lateral lobe coincides with the involution of the shell; that is to say, a horizontal line drawn transversely across the septum touching the siphonal part of the preceding whorl, reaches the surface of the whorl at the interior or lower margin of the second lateral lobe, or (as in most *Arcestes*) in the middle of the first auxiliary one. This is not the case in the Artinsk *Goniatites*. If we consider attentively the drawing of the sutures of these species as they are represented in the Geology of Prussia, or in the Proceedings of the Prussian Mineralogical Society, Vol. IX, we find, as far as it can be made out from the drawing alone, that there exists either no proper siphonal lobe, or the first lateral is united with the siphonal, and only the second lateral is distinct, or finally the second lateral is entirely absent. This difference seems to me so essential, that I think it barely advisable to unite the Artinsk *Goniatites* generically with *Arcestes*, as Mojsisovics seems inclined to do; they will have to be kept separate, under a distinct generic designation.

The two species I have to describe from the Salt-range cannot be united with any of the developmental groups hitherto distinguished within the genus *Arcestes*, as all connecting links between them and the triassic species which have been described up to the present are as yet unknown.

Both the Salt-range species have been found in the upper region of the Productus-limestone.

1. Arcestes antiquus, Waagen, sp. Pl. I, fig. 10.

The only specimen I have collected of this species is not entire, nearly half of it being broken away, and even what remains is greatly weather-worn, and nothing can be observed but the general form of the cast, and the sutures, as no trace of the shell remains.

The general form of the specimen is somewhat lenticular, higher than broad, with a broadly rounded siphonal part, which appears a very little narrower on the last whorl, than in the preceding ones. What remains of the last whorl belongs to the body chamber. The umbilicus is very small and deep, with walls which are a little bent inwards near the umbilical suture, and form no umbilical edge, where they unite with the side parts of the shell. The involution of the shell is, in consequence of the small umbilicus, very great (not as large, however, as in *Cyclolobus oldhami*), and also the increase of the whorls is more rapid than in the mentioned species. Varices, or any other ornamentation of the shell, are entirely absent.

The sutures, which I succeeded with great difficulty in making visible, are very interesting. The direction of them is about radial, as in other *Ammonites*, the single lobes and saddles slowly decreasing in size as they approach the umbilicus.

The largest of all the lobes is the siphonal one; it terminates in two short broad branches, each of which bears two fingers at its end. The external saddle is broadly rounded, without any indentation. The first lateral lobe is somewhat shorter and narrower than the siphonal, terminating with three unequal fingers at its end. The first lateral saddle is narrower and shorter than the external, and is not quite rounded, but bears a slight indentation at its base or its side. The second lateral lobe is very irregular in shape, and barely shorter than the first lateral; it terminates in two or three irregular fingers. The second lateral saddle is shorter than the first, having a strong indentation near its base. The following auxiliary lobes are rather irregular in shape, generally terminating in three distinct fingers, but gradually more reduced and simpler in their form as they approach the umbilicus. The auxiliary saddles sometimes bear indentations, sometimes not. There are seven to eight auxiliary lobes, and six or seven auxiliary saddles.

The most curious feature of these sutures is their irregularity. In the more recent *Ammonites* the single sutures following one another are very much alike, and the general form of the single lobes and saddles remains pretty constant as the shell increases in size, only additional fingers are put in in quite a regular manner. This is not the case in our species. If we consider the three sutures drawn on Pl. I, fig. 10 *c*, which is drawn with the utmost care, and represents the peculiarities of the single sutures with perfect correctness, we find that the termination of each single lobe is differently shaped in each succeeding suture, also that the indentations of the single saddles come and disappear in the succeeding sutures quite irregularly, so it appears that the secondary characters of the sutures are not yet individualised, but only put forth tentatively, to be changed according to convenience during the growth of the shell.

We can observe the same on the siphonal lobe. Of the two successive siphonal lobes I have exposed, the one shows an indentation in the middle of the "siphonal tubercle" (as it has been called by Mojsisovics) suggestive of the direction backwards of the siphonal funnel, whilst in the other this indentation is absent, but on the right branch of the lobe a slight indentation appears in its place.

The dimensions of the specimen are as follows:—

	mm.
Diameter of the shell (about)	66
„ of the umbilicus	3
Height of the aperture from the umbilical suture	40
„ of the aperture from the preceding whorl	17
Thickness of the aperture	27
„ of the preceding whorl	21

Locality and geological position.—The only specimen which exists of this species was collected by me at Kufri, on the road from Shahpur to Sukesar mountain. A very complete section from the upper portion of the Productus-limestone up to the nummulitic strata is here exposed; it has been published on page 224 of

Wynne's report, from my notes, except the headings ("Nummulitic, Trias, Carboniferous") which are Wynne's, and which are for the most part wrongly placed. The specimen here under consideration was found by me in the lowest division of the section (bed No. 14 of my note-book), and thus belongs to the fauna of the upper division of the Productus-limestone. There can be no doubt as to the geological position of this species.

Remarks.—There are very few forms with which our species can be compared; only some species of *Goniatites* might require some notice. In the newer palæozoic sandstone of Artinsk there have been found some Cephalopoda, which in their general type differ so far from all the Cephalopoda described hitherto from any of the palæozoic strata, that the special attention of palæontologists has long since been fixed upon them. Among the lot there are also three species of so called *Goniatites*, which in their general appearance bear some similarity to *Arcestes antiquus*. It is especially the sutures that are much like those in our species; however, as I have already remarked above, in the Artinsk species, the arrangement of the lobes is entirely different, and indicates a state of development far below that which is observed in our *Arcestes*. In general form *Gon. soboleskianus* has the greatest resemblance; but the slight sculpture visible on this species is strongly bent backwards on the siphonal part of the shell, a feature which is not observable on our species. It is, however, very much to be regretted that the shell has been entirely lost from our specimen, so that it cannot be ascertained whether the striæ of growth were bent backwards on the siphonal part of it or not. As the matter stands, there is no doubt that our species can be well distinguished from the Artinsk *Goniatites*, by the absence of every kind of sculpture, and from all the species of *Arcestes* hitherto described, by the simple goniatitic lobes.

2. Arcestes priscus, Waagen, n. sp. Pl. II, fig. 6.

Besides the one just described, another species of *Arcestes* has been detected by me in the palæozoic strata of the Salt-range. Though there is only one specimen of it, yet it exhibits sufficiently distinct characters to be described under a special name.

The general form of the shell is thick lenticular, with a broadly rounded siphonal part, and a very small umbilicus. The umbilicus is deep, surrounded by perpendicular walls without umbilical edge. The whorls are deeply embracing each other, so that about half the height of the whorl is filled up by the preceding one. The shell is entirely smooth, and no sculpture whatever is observable on it.

The lobes are very characteristic, and much more complicated than in the preceding species, though the specimen is much smaller. I did not succeed in exposing the entire suture, but some of the smaller auxiliary lobes are wanting. The largest of all the lobes is undoubtedly the siphonal lobe, which is very deeply divided into

two branches by a large siphonal tubercle, and is exactly as broad as long; both branches are slightly fingered at their termination, as well as at their sides. The external saddle is rather narrow, with monophyllic termination. The first lateral lobe is broad and short, shorter than the siphonal, terminating in three or four fingers, and also slightly fingered at its sides. The first lateral saddle is shorter, but as broad as the external, terminating with two phylla. The second lateral lobe is much narrower than the first, otherwise in shape very similar to the latter. The second lateral saddle is shorter than the first, broad and monophyllic. The auxiliary lobes and saddles bear no particular features worth mentioning. I can distinguish four of them, but very likely there were six; they are gradually diminishing in size as they approach the umbilicus. Also in this species it is observable that the minor details of the lobes and saddles are not exactly alike in two succeeding sutures.

Highly interesting are the antisiphonal or internal sutures, which are well seen on the whole surface of the specimen, covering it in fact entirely, as the remnant of a whorl which had been broken off. It would have been very easy to mistake these for the proper lobes of the species, and this would then have been described without any doubt as a typical *Goniatite;* whilst the proper sutures of the specimen only became visible after the removal of these remnants of the internal sutures of an outer whorl, and of the covering shelly layer of the succeeding one. In these internal sutures the "goniatitic" appearance is strictly preserved, the saddles being all entire, without any indentation, and the lobes terminating very regularly in three points, of which the middle one is the most prominent. The antisiphonal lobe is conspicuous by its larger size. There are on both sides of the antisiphonal lobe nine lobes, which diminish gradually in size as they approach the umbilical suture.

The dimensions of the specimen as are follows:—

	mm.
Diameter of the shell	28
„ of the umbilicus	3·5
Height of the aperture from the umbilical suture	15
„ „ „ from the preceding whorl	6·5
Thickness of the aperture	15

Locality and geological position.—The only specimen of this species which has been discovered up to the present was collected by me at Khúra, in the upper division of the Productus-limestone, and there can be no doubt as to the geological position of this species, as well as of those described before.

Remarks.—There are but very few species which might be compared with our form. From *Arc. antiquus*, described above, our species is easily distinguishable by the more complicated sutures. Of other species one group of forms, which contains up to the present not more than about three species, is somewhat more closely allied, and requires special notice. In his description of the Muschelkalk

Cephalopoda of the Alps, Beyrich figures a small Ammonite from Ladak as *Amm. brachyphyllus*. This he considers as type for a group of forms which contains also *Amm. difissus*, Salter (non Hau.), and an indeterminate species of an Ammonite, figured by Salter in the Palæontology of Niti, Plate 7, fig. 4. Of these species principally the last bears some resemblance in its sutures to *Arcestes priscus;* but in this, as in all the species of the "*brachyphyllus* Group," the little development of the auxiliary lobes establishes a most decided distinction between these and our species, whilst the great number of auxiliary lobes in the latter approaches it more to the true *Arcestes*.

Among the more recent forms of *Arcestes* our species resembles most those forms which have been united by Mojsisovics in the group of *Arcestes intuslabiatus*. Chiefly the young of *Arcestes intuslabiatus* itself have got sutures which in many respects resemble those of our species, and the generic identity of both can barely be doubted. As to specific resemblance this is very small indeed; and nobody will, I think, in only looking at the interior sutures of the Indian species, advocate a specific identification of it with any of the triassic *Arcestes*.

The truly ammonitic exterior sutures, and the truly goniatitic interior ones, in *Arcestes priscus* are features which characterise this species as a truly transitional form, between the older so called *Goniatites* and the *Arcestes* proper.

XENODISCUS, Waagen, n. gen.

1863. *Goniatites* (de Haan) de Koninck: Fossiles Paleoz. de l' Inde, p. 7.
1872. *Ceratites* (de Haan) Waagen: Mem. Geol. Surv. of India, IX, p. 355.

In 1872 I described a species of a Cephalopod which by the nature of its sutures seemed to belong to that division of the *Ammonitidæ* which had received the name of *Ceratites* by former writers. Since that time our knowledge of the *Ammonitidæ* has progressed very rapidly; and to-day we are already in a position to affirm positively that the so-called *Ceratites*, as well as the *Ammonites* proper, have sprung up from very different roots, and that also among the *Ceratites* animals of very different organisation have been included, as the distinction of the genus was one-sidedly based on the character of the sutures alone.

The most able exposition of the forms hitherto generally considered as *Ceratites* we find in Beyrich's Cephalopoda of the Muschelkalk of the Alps, and according to this writer there exist five different groups of these shells: (1) the group of *Amm. nodosus*, (2) the group of *Amm. cassianus*, (3) the group of *Amm. modestus*, Hau., (4) the group of *Amm. buchi*, and (5) the group of *Amm. peregrinus*, Beyr. The first of these groups has been united by Mojsisovics with Laube's genus *Trachyceras*, the second has furnished the type for a new genus *Tyrolites* of Mojsisovics, the third and fourth have not yet been studied more in detail, and the fifth includes forms for which I propose the name *Xenodiscus*.

The general form of the shell in this genus is flat discoidal, with compressed whorls, perfectly rounded on the siphonal side. The umbilicus is mostly large, and the whorls generally only slightly embracing each other. The shell is either entirely smooth, or furnished with distant rounded folds which are thickest near the umbilical margin of the whorls, or with numerous slight plications which are straight on the sides of the whorl and slightly turned towards the front near the siphonal margin. The sutures are very simple; the siphonal and two lateral lobes always well developed, also a sutural lobe generally, but auxiliary lobes are generally absent. The lobes are furnished with a slight indentation at their termination, the saddles rounded, entire, without any indentation. The internal sutures show only one large antisiphonal lobe which terminates in two long sharp points.

In one of the specimens under description, the entire body chamber is preserved; it occupies not quite one whorl, and becomes entirely smooth towards the aperture. The aperture itself is very simple, the siphonal part, and a point in the middle of each side, very slightly projecting.

Our genus is not very difficult to distinguish from other genera more or less allied to it. The genus *Tyrolites* differs greatly, by the absence of the second lateral lobe, and by the sculpture, which is always most prominent on the siphonal margin; the genus *Trachyceras* has its body chamber much shorter, and the system of sculpture on the shell is entirely different.

The principal development of the genus takes place in the Ceratite beds of the Salt-range, wherefrom I shall have to describe a number of species. In the Productus-limestone only two species of the genus have been found up to the present, which I propose to describe under the names of *Xenodiscus plicatus* and *Xenodiscus carbonarius*.

It is very difficult to say in what connection our genus may stand with older or more recent forms. If we look through the different forms of *Goniatites*, no other species resembles more closely our genus than *Goniatites lyoni*, Meek and Worthen, of the Chemung group (devonian) of the state of New York, and of the Kinderhook formations (carboniferous) of Illinois. This species has rounded compressed whorls like the species belonging to *Xenodiscus*, and very distinctly developed two lateral lobes; only the siphonal lobe is yet undivided, without siphonal tubercle. Of more recent forms the older species of *Aegoceras* like *Aeg. incultum*, Beyr., *Aeg. salteri*, Beyr., etc., in their general appearance bear a certain resemblance to our genus. They have also two lateral and one strongly developed sutural lobe, which often is divided in several auxiliary ones. The antisiphonal lobe is also terminating in two distinct fingers. Thus it appears probable that the genus *Aegoceras* has derived its origin from some form of *Xenodiscus*.

1. Xenodiscus plicatus, Waagen, n. sp. Pl. II, fig. 1.

The form of this species is very characteristic, and to be easily recognised.

The general form of the shell is flat disciform, with a large umbilicus and a tolerably broadly rounded siphonal side. The whorls are compressed, rectangular, thickest near the umbilical margin. The umbilicus is shallow, surrounded by sloping walls, which form with the sides of the whorls an obtuse umbilical edge.

The whorls are higher than broad, and are on the inner volutions covered with simple, strong, prominent folds, which occur to the number of eight to eleven on one circuit. They disappear, however, rapidly towards the end of the body chamber, which in its latter half is nearly quite smooth.

The transverse section of the body chamber differs slightly from that of the preceding whorls, as it is more rectangular, the siphonal part of the shell being slightly depressed, and the sides of the whorl more or less parallel. In the inner whorls, on the contrary, the siphonal part is more prominent and narrower, and the sides of the whorl diverge slightly towards the umbilical edge, where the largest transverse diameter of the whorl is situated.

The aperture of the body chamber is almost entirely preserved in one of the specimens under description. It is very simple. There is a short ventral lobe projecting on the siphonal part of the aperture, which forms a slightly prominent semicircle. The sides are nearly quite straight, only very little projecting in the middle, not showing in any degree the outline of a "falciform margin," and go straight down to the umbilical suture.

The sutures of the septa are very simple. There is a small short siphonal lobe, about twice as broad as long, terminating in two short branches, each of which is crenulated at its lower extremity. The external saddle is entire, without indentation, as broad as the siphonal lobe. The first lateral lobe is twice as long, but narrower than the siphonal, and terminating at its lower extremity with a number of small crenulations. The first lateral saddle is much narrower, but not reaching further up than the external one; there is no trace of any indentation. The second lateral lobe is about as long as the siphonal and very broad, slightly crenulated at its lower extremity. The second lateral saddle is very small, and, as it seems, bordered at its inner margin by a short sutural lobe.

The dimensions of a specimen from Katwahi are as follows:—

	mm.
Diameter of the shell	65
„ „ „ umbilicus	27
Height of the aperture from the umbilical suture	22
„ „ „ „ „ „ preceding whorl	19
„ „ „ preceding whorl from the umbilical suture	13
Thickness of the aperture at the siphonal part	13
„ „ „ „ „ „ umbilical edge	12
„ „ „ preceding whorl at the siphonal part	6
„ „ „ „ „ „ „ umbilical edge	10

Locality and geological position.—The only perfect specimen of this species in the collection was brought by Mr. Wynne from Katwahi. It is preserved in a yellow sandy marl rock, in which I also observed, in cleaning the specimen, a piece of *Dentalium herculeum*, Kon., and an *Athyris subtilita*. There is therefore no question as to this piece of rock containing the three species coming from the upper division of the Productus-limestone. Fragments of the same species (*Xenodiscus plicatus*) from Jabi have been already mentioned by me when describing the Cephalopoda of that locality in the Memoirs Geological Survey, Vol. IX, without giving them, however, any name. There is also a small fragment from another locality. This was collected by myself at Chidru, in the Cephalopoda bed of the upper Productus-limestone, together with a lot of other fossils, among which there were also many specimens of *Xenodiscus carbonarius*, the description of which will follow. *Xenodiscus plicatus* is, however, always much scarcer than the other species just mentioned.

Remarks.—*Xenodiscus plicatus* is very easy to be distinguished from all other forms of the same genus by the strong folds which cover the sides of the whorls. All the fragments at my disposal, however, do not show these folds equally strong, and, if better materials were procurable, some intermediate form between this species and *Xenod. carbonarius* might possibly be distinguishable. As it stands, *Xenod. plicatus* is excellently characterised by its folds, and by whorls which are far thicker than those of the following species.

2. Xenodiscus carbonarius, Waagen. Pl. II, figs. 2-5.

1872. *Ceratites carbonarius*, Waagen : Mem. Geol. Surv. India, Vol. IX, p. 355, Pl. I, figs. 2 & 3.

The general form of the shell is flat discoidal, with a very large and shallow umbilicus.

The whorls are very compressed, much higher than broad, with flattened sides and a perfectly rounded siphonal part. They are nearly quite smooth on the inner volutions of the shell, but the last whorl, which is almost entirely occupied by the body chamber, is covered by numerous low folds, which are nearly straight on the middle of the sides of the whorl, and bent slightly towards the front near the siphonal region. Towards the aperture of the body chamber these folds disappear, and the shell becomes again perfectly smooth. The folds are very irregular in strength and size, and often so indistinct that they are difficult to trace. The whorls embrace each other very little, but different specimens in different stages of growth do not show quite identical characters in this respect.

The umbilicus is surrounded by sloping walls, which form, however, no distinct umbilical edge in uniting with the sides of the whorls.

The form of the shell changes very little during the growth of the animal, but nevertheless the transverse sections of the whorls in young and in old specimens

show some differences. The smallest specimen I have got for description measured about 14 mm. in diameter. At that size the height of the last whorl is 6 mm., whilst the thickness is 5 mm. In a specimen of 60 mm. in diameter, on the contrary, the height of the last whorl is 20 mm. and the thickness 10 mm., in other words, in the young shell the whorls are about as thick as they are high, whilst in adult ones the height of the whorl is equal to twice its thickness.

In none of the specimens is the body chamber entirely preserved, but it must have occupied nearly one whorl. The form of the aperture can be judged from the form of the folds which cover the sides of the shell, and from them it appears that it must have been very similar to that of *Xenodiscus plicatus*, the lateral margins being nearly straight, the siphonal part projecting. The aperture itself is not preserved in any of the specimens.

The sutures are very simple, showing one siphonal and two lateral lobes, and one external and two lateral saddles. The saddles are all entire without indentation. The siphonal lobe is very short, but nearly twice as broad as long, divided into two short little dentated branches. The external saddle is short and not quite as broad as the siphonal lobe. The first lateral lobe is only half as broad, but twice as long as the siphonal one; it terminates in a finely serrated ogival arch. The first lateral saddle is much narrower than the external, about as broad as the first lateral lobe, but reaching much further up than the former. The second lateral lobe is shorter, but as broad as the first, it terminates in a finely serrated arch. The second lateral saddle is much shorter than the first and not quite semicircular, but slightly depressed at its upper extremity; it terminates at the umbilical suture of the whorl.

The internal part of the suture is excellently preserved in a small fragment of this species, which was collected by Mr. Wynne at Khund Ghât. It shows that from the umbilical suture of the whorl, the sutural line ascends again, forming a short but broad internal saddle, which is followed towards the middle by a long and narrow antisiphonal lobe, terminating at its lower extremity in two long sharply pointed fingers.

The dimensions of three specimens, No. I from Jabi, Nos. II and III from Chidru, are as follows:—

	I.	II.	III.
	mm.	mm.	mm.
Diameter of the shell	103	61	48
„ „ „ umbilicus	53	27	21
Height of the aperture from the umbilical suture	27	20	15
„ „ „ „ from the preceding whorl	? 25	? 19	14·5
Thickness of the aperture	14	10	8

Locality and geological position.—The locality where I first detected specimens of this species was Chidru, where I collected them together with a lot of palæozoic fossils in the upper division of the Productus-limestone, in a bed which is indicated in my section printed in Wynne's report, p. 248. The species is not

rare at that locality, but it is difficult to get any well-preserved specimen. During my short stay at the locality I collected three tolerably complete specimens and fragments of five more. Later on I got more complete materials at Jabi, in the same bed of the upper Productus-limestone. They occurred there together with *Cyclolobus oldhami* and *Sageceras primas*, and I got two tolerably complete specimens and fragments of nine others. A fragment of a somewhat thicker variety was found by Wynne at Khund Ghât, also in the upper division of the Productus-limestone.

Remarks.—Though this species is not at all rare in the Salt-range deposits, yet it is very difficult to get tolerably complete specimens. Among all the materials I collected there was but one fragment that showed the sutures clearly distinct, and from which the drawing on Plate II was executed.

There are several species which might be compared with our form, and in the second part of this work I shall have to describe quite a number of allied forms. Up to the present only the species described by de Koninck can come into consideration, and of these it is chiefly *Goniatites gangaticus* which is nearly allied; however, it is not difficult to distinguish this species from the one just described, by the different sutures and the less flattened sides of the whorls. Other species, like *Ceratites, Buchianus*, &c., which show sutures very similar to those of *Xenodiscus carbonarius*, have a flattened siphonal part of the shell, and cannot, therefore, be compared with the latter species.

Of other species only *Ammonites peregrinus*, Beyrich, or *Amm. onustus*, Opp., both from rocks of unknown age of the North-West Himalayas, are allied; but they bear in their sutures sufficiently distinct characters to afford a specific separation of both from our Salt-range fossil.

The distinctive characters of this species from *Xenodiscus plicatus* I have indicated already in describing the latter form. They consist of smooth and more compressed whorls in *Xenodiscus carbonarius*, and also the sutures are somewhat different.

Genus: SAGECERAS, Mojsisovics.

1845. *Goniatites* (Haan) Verneuil: Russia and the Ural Mountains, II, p. 375, pl. XXVI, fig. 6.
1847. *Goniatites* (Haan) Haner: Haidinger's Naturw. Abhandl. I, p. 264, pl. VIII, figs. 9-11.
1863. *Ceratites* (Haan) Koninck: Fossiles Paléozoiques de l'Inde, p. 11, pl. III, fig. 5.
1864. *Ceratites* (Haan) Gabb: Palæontology of California, I, p. 22, pl. V, figs. 8-10.
1872. *Goniatites* (Haan) Waagen: Mem. Geol. Surv. of India, IX, p. 356.
1872. *Sageceras*, Mojsisovics: Verhandl. Geolog. Reichsanst, 1872, p. 316.
1873. *Sageceras*, Mojsisovics: Gebirge um Hallstadt, I, p. 69, pl. XXIV, figs. 1-6.
1874. *Sageceras* (Mojs.) Karpinsky: Verhandl. Kais. Russ. Mineralog. Geos., IX, p. 286, pl. XII, figs. 9-14.

Already in my short note "on the occurrence of *Ammonites* associated with *Ceratites* and *Goniatites* in the carboniferous deposits of the Salt-range," I indicated that the shell described there as *Goniatites primas* was very likely the type of a

new genus of *Ammonitidæ*, to establish which there were, however, at that time not sufficient materials at hand. Immediately after the arrival of my note in Europe, Mojsisovics, on reviewing it, established the genus *Sageceras*, which he had already at an earlier date recognised and distinguished from triassic species.

The genus *Sageceras* is one of those among the *Ammonitidæ* which from its sutures alone may most easily be recognised, and seems to compose one of the most natural groups of forms imaginable. Yet if we go more into details, we find that the genus can easily be divided into two well-defined sections, each of which contains several species.

Mojsisovics has rightly put some stress on the singular feature of the siphonal lobe in some of the species of this genus; but it is very remarkable that all the species cannot boast of this peculiarity. That species which is longest known to science, *Sag. orbignyanum*, Vern., exhibits most clearly the peculiar arrangement of the siphonal lobe; whilst the species *Sag. haidingeri*, described two years later by Hauer, is quite different in that respect. The first is a palæozoic, the second a mesozoic species. Up to the present, no transitional forms between the two types have been detected, and thus two sections can be established within the genus, which might in the future even prove to be of generic value. It is only to be regretted that species belonging to this genus are generally so very rare that it is difficult to get sufficient materials for more minute investigations into the structure of the shells.

Altogether eight species of this genus are known up to the present, of which four (*Sag. haidingeri*, H., *Sag. gabbi*, Mojs., *Sag. hauerianum*, Kon., and *Sag. zsigmondyi*, Bokh.) show the siphonal lobe very little developed; whilst the remaining four, (*Sag. orbignyanum*, Vern., *Sag. artiense*, Gruenen, *Sag. sakmaræ*, Kaop., and *Sag. primas*, Waagen) have got a very strangely developed siphonal lobe.

I shall therefore distinguish in the following descriptions two sections of the genus: 1, Section of *Sag. haidingeri*, Hau., and 2, Section of *Sag. orbignyanum*, Vern. It is worthy of notice that the first section is of chiefly mesozoic distribution, whilst the second is entirely palæozoic, three of the species occurring in the sandstone of Artinsk, and one in the Productus-limestone of the Salt-range.

The materials at my disposal are, I regret to say, not sufficient to add anything of importance to the proper knowledge of the genus. It would have been of peculiar interest to ascertain whether in the forms with a well-developed siphonal lobe the same augmentation of the adventive lobes takes place as has been observed to occur in *Sag. haidingeri;* but the single fragmentary specimen I have got for description exhibits only five consecutive sutural lines, which are all perfectly alike.

There are two species of *Sageceras* known to occur in the Salt-range, one belonging to the first and one to the second section.

I.—Section of *Sageceras haidingeri*.

1. Sageceras hauerianum, Koninck. Pl. II, fig. 8.

1863. *Ceratites hauerianus*, Koninck: Fossiles Paléozoiques de l'Inde, p. 11, pl. III, fig. 5.

As I have not got any specimen of this species, I can only quote M. de Koninck's description:[1]

"This species, of which I have found unfortunately only a single fragment among the fossils of Dr. Fleming, is rather nearly allied to *Gon. haidingeri*, Hau., which also might well be considered as a *Ceratite*.

"As in the latter species, the sutures are very numerous and composed of a great number of very narrow lobes and saddles, of which those situated more towards the middle of the sides are a little larger than the others; there are five of them. Unfortunately the specimen is so badly preserved that it is impossible to describe exactly the shape of the parts of its whorls, which have each eight divisions at least. The back is keeled, and tolerably sharp. The thickness of the shell must have been about $2\frac{1}{2}$ cent. The aperture seen from the front must have been sub-triangular, as is shown in fig. 5*a*."

Locality and geological position.—There is no indication as to what locality Dr. Fleming's specimen came from. It is therefore extremely difficult to decide on the geological position it occupied. Every research on the spot for this species was absolutely fruitless, as well in the Productus-limestone as in the Ceratite beds, and I therefore am quite unable to give any reliable information as to its geological age. The general relations of the species point more to a mesozoic than a palæozoic age, but such general relations are very untrustworthy guides. I have mentioned the species here on account of its generic identity with the following one.

Remarks.—It would have been of much value if I could have given a new figure of this species, as de Koninck's drawing is rather unsatisfactory; but all my endeavours to hunt up de Koninck's original specimen have been absolutely fruitless up to the present. De Koninck states that the greater part of Dr. Fleming's collection had been deposited by the latter in the "Museum of Calcutta." In the Asiatic Society's collections there, however, nothing could be found of them; and what other "Museum" could be referred to, I do not know. However, I may yet succeed in getting at those originals, and then I propose to give a new figure of the present species on some later plate.

II.—Section of *Sageceras orbignyanum*, Vern.

2. Sageceras primas, Waagen. Pl. II, fig. 7.

1872. *Goniatites primas*, Waagen: Mem. Geol. Surv. of India, Vol. IX, p. 365, pl. I, fig. 4.
1873. *Sageceras primas* (Waagen) Mojsisovics: Gebirge um Hallstadt, I, p. 69.

[1] In Mémoires de la Société Royale des Sciences de Liège, Vol. XVIII, p. 563: also, Quar. Jour. Geol. Soc., London, Vol. XIX, p. 12: Proc. Nov. 5, 1862.

There is only one fragment of a cast of this species, but it is sufficient to ascertain the general form of the shell.

The shell is flat disciform, with a very small and not very deep umbilicus, and a narrow siphonal part, which bears two sharp longitudinal ridges, between which a rather deep excavation is observable.

The whorls are perfectly smooth, compressed, with flat sides, which are slightly inflated a little above the umbilicus, and descend from there in an elegant curve to the umbilical suture, without forming an umbilical edge or presenting distinct umbilical walls. The whorls envelope each other almost completely, and increase at the same time very rapidly in height, an inner whorl showing only about one-third of the height of the outer one. The greatest thickness of the whorls is situated within the lower third of the height of the whorl.

Most difficult is it to describe the sutures, as the designations which are generally used for doing so do not hold good for this shell. Principally, there is nothing which could properly be designated as a siphonal lobe. In the excavation between the two ridges on the siphonal part of the whorl, there is a long, narrow, pointed lobe, serrated laterally, about six times as long as it is broad, bounded on both sides by narrow saddles. The lower pointed termination of this lobe lies in the same radius of the shell as that touching the last auxiliary lobes, where they reach the umbilical suture. The two narrow saddles limiting this lobe on both sides reach up very far, and bear four deep indentations on their umbilical side. They are followed by a short lobe, about twice as long as broad, which has a finger on each side about in the middle of its height and terminates in a leaf-shaped pointed part. The saddle which follows next is very short, reaching up only to the first indentation of the narrow siphonal saddle, and is about half as long as it is broad; there is no indentation on its upper extremity. After this saddle there follow three lobes, which are the most conspicuous of the whole set, reaching somewhat further down than the three lobes of the siphonal apparatus. Each of them bears a finger in the middle of its height on each side, and terminates in two leaf-shaped pointed parts. The lobes are separated by narrow rounded saddles, which are about equal in size, and reach no further up than the saddle following next to the siphonal apparatus. The next lobe, the fourth, from the siphonal apparatus, is shorter than the three preceding ones, but otherwise very similar in shape. From this there follow yet seven lobes, rapidly diminishing in size as they approach the umbilical suture, the larger ones of them still bear lateral fingers, the smaller not, but all terminate in two pointed leaf-shaped branches. The saddles are all rather narrow, never reaching far up, and perfectly rounded, without indentation in their upper extremity. If we consider the point up to which the preceding whorl reaches into the succeeding one, we find that that there are five or six lobes, besides the siphonal apparatus, standing above the line drawn transversely across the septum at that point. It is therefore very difficult to decide which of those lobes ought to be considered as representing the lateral lobes of other Ammonites,

as the most conspicuous lobes on the sides of the shell are the fourth, fifth, and sixth, above the line specified. Besides this singular arrangement of the lateral lobes, the most strange feature of the whole sutural line is the shifting towards the front of the whole siphonal apparatus, so as to make the three lobes of which it is composed appear much shorter than the lateral lobes, though they are in reality much longer.

Though there is only a fragment of this species, yet if we complete the spiral from the short length of it which is preserved, we can succeed in getting a tolerably complete idea of the general outline and the dimensions of the whole shell. The following measurements are taken in this way, but it must be remembered that they can be only approximate. The dimensions of the shell seem to have been the following:—

	mm.
Diameter of the shell (about)	114
„ „ „ umbilicus (about)	10
Height of the last whorl from the umbilical suture	59
„ „ „ „ „ from the preceding whorl	39
„ „ „ preceding whorl from the umbilical suture	? 25
Thickness of the last whorl	23

Locality and geological position.—The specimen from which this species has been described was collected by myself at Jabi, in exactly the same bed which has also furnished several specimens of *Xenodiscus carbonarius* and *Cyclolobus oldhami*. I took it with my own hands out of the rock *in situ*, and there can exist, therefore, not the slightest doubt as to its occurring in the upper division of the Productus-limestone. The close resemblance of this species to some of the forms described from the sandstone of Artinsk is a feature which will be of value for the exact determination of the age of the bed in which it occurs, in comparison with the standard table of formations generally adopted in science.

Remarks.—There are three species with which our form can be compared, *Sag. artiense*, Gruenw., *Sag. sakmaræ*, Karp., and *Sag. orbignyanum*, Vern. The first two are not difficult to distinguish from our species by their somewhat broader siphonal side of the shell, which leaves even two rows of crenulations in *Sag. sakmaræ;* but the last of the three requires a closer comparison to find the specific differences. The general form of the shell, the doubly-keeled narrow siphonal side, the small umbilicus, and the transverse section of the whorls, are very much alike in both species; a marked difference appears, however, immediately we compare the sutures of the septa. The narrow siphonal lobe is nearly identical in shape, but the whole siphonal apparatus is not placed so far towards the front as in our species; there are not three principal lateral lobes, but only one; and in all the lobes the lateral fingers, which are so conspicuous in *Sag. primas*, are absent in the Prussian species. On the whole, it is obvious that in *Sag. orbignyanum* the sutures are much less complicated, and the strange features of it, which I have pointed out above, are less strongly developed than in the Indian form. If we accept the observation so often made—that the general tendency of development in the

Ammonites is, in each single developmental series, to complicate more and more the sutures, as the development of the series progresses in time—as indicating a general law of development for the *Ammonites*, we are led to believe that very likely *Sag. orbignyanum*, Vern., sp., and *Sag. primas*, W., may be in developmental connection. Once this is admitted, it becomes very probable that *Sag. orbignyanum* must have been prior in time, as it exhibits sutures which are less complicated than those of *Sag. primas;* whilst the latter must have succeeded the former after a more or less long interval, during which the more complicated sutures of *Sag. primas* have been developed by transmutation. Thus it would appear that the beds in which *Sag. primas* has been found must have been deposited at a later period than the sandstone of Artinsk which has furnished the specimens of *Sag. orbignyanum*.

Order: TETRABRANCHIATA.

Family: *NAUTILIDÆ*.

Genus: NAUTILUS, Linné.[1]

As might have been expected in beds of upper palæozoic age, the genus *Nautilus* is abundantly represented in the Productus-limestone of the Salt-range. It is a strange fact that among the materials brought by Dr. Fleming from that ground, only one species of *Nautilus* was included, and that another species could be assigned, but doubtfully, to the Productus-limestone formation. The species which were described from Dr. Fleming's collection by de Koninck were: *Nautilus flemingi*, Kon., undoubtedly coming from palæozoic strata, and *Naut. burtini galeotti*, very likely of nummulitic age. The deficiency in the knowledge of the fauna of the Productus-limestone, as indicated by only a single species of *Nautilus* being known, has been largely filled up by the collections made by Mr. Wynne and myself as I am now in a position to describe not less than ten species of *Nautilus* from these beds. Altogether there have been described up to the present about 115 to 120 species of *Nautilus* from the newer palæozoic formations (carboniferous and permian), and this number already sufficiently indicated the preponderance of the genus during those times. Whilst in the silurian formation only about twenty-two species were present, the number during the devonian period was as low as seventeen, and only in carboniferous times the genus attained such an enormous development as it never attained again in more recent formations.

It is only natural that among the great number of species of *Nautilus* existing during the newer palæozoic formations several divisions can be distinguished. Several attempts have been made to sub-divide the genus into several subgenera; but,

[1] Since this part of the manuscript was completed, news of the recent publication of a large work on Carboniferous *Nautilidæ* by Mons. de Koninck have reached me. A letter from Mons. de Koninck kindly informed me that a copy of the work was on its way to the library of the Geological Institute here, but after having waited for some weeks in vain, the work not having yet arrived, I am forced to send this manuscript to press and to postpone references to de Koninck's work to the general conclusions.

though there are many indications to show that the animals inhabiting the differently shaped shells must have been of somewhat different organization, at present the means have not yet been detected to discover in what manner the peculiarities of the shells must have been related to the animals, and thus all attempts in the direction of sub-dividing the genus have been without a firm base, and therefore could not be maintained. The only way which in the end might lead to a definitive solution of the question—to study carefully and in detail the development in time of the different series of forms, by which the present genus *Nautilus* has been composed—has not yet been attempted in a single instance; and thus the classification of the forms belonging to the genus has not yet made much progress since the investigations of Quenstedt, and the sub-divisions he proposed must still be considered as the most practicable ones.

It is not possible for me here to attempt a new classification of the species of *Nautilus;* but there is no doubt, that the *Nautili* as well as the *Ammonites* can be divided very properly into several groups, which, if properly defined, might very well prove to be of at least sub-generic value. And not only can such large divisions be distinguished, but also developmental series, such as have been described among the *Ammonites*, are well characterised within the genus.

The divisions which have been pointed out to exist among the *Nautili* by Quenstedt are the following: (1) *Imperfecti*, (2) *Moniliferi*, (3) *Striati*, (4) *Simplices*, (5) *Undulati*, (6) *Aganites*. Of these the first is chiefly palæozoic, whilst the others for the greater part include mesozoic species. It is evident that these sub-divisions are of very unequal value. Whilst some, like the *Moniliferi*, include only a very few species, and represent not more than part of a developmental series; others, like the *Imperfecti*, comprise such a number of species that it becomes unavoidable to create some further groups. Attempts in this direction have been made already by several authors, and American and other writers have created several generic designations for different forms. I need only mention the names *Temnocheilus*, M'Coy, *Discites*, M'Coy, *Trematodiscus*, M. and W., *Endolobus*, M. and W., *Cryptoceras*, Orb., etc., which all have been created to include species of Quenstedt's *Imperfecti*, and the generic distinction of all of which is more than doubtful. However, it is perfectly clear from all this, that the *Imperfecti* of Quenstedt cannot be retained as equal in value to his other divisions.

The species of *Nautilus*, which have been found in the Productus-limestone of the Salt-range, must be counted for the greater part with the *Imperfecti;* there is, however, one which in its general appearance resembles more closely some mesozoic form, and must be considered as very likely belonging to the *Simplices* of Quenstedt. Among the *Imperfecti* from the Salt-range I am able to distinguish two divisions which can easily be recognised from the general form of the shell. The first division I call the *Tuberculati*, which possess broad, more or less depressed whorls ornamented at their sides with a row of more or less closely arranged tubercles, which are sometimes transformed into thick, tuberculated, radial ridges. The

type of this division is *Naut. tuberculatus*, Sow.: besides this there have been described a number of allied species in Europe, Asia, and America, ranging from the devonian to the triassic formation. The second division I am able to distinguish I shall call the *Ophionei;* the shell shows a very large umbilicus, the whorls are compressed, but without any ridges or ornamentation, the siphonal part perfectly rounded; but in this as well as in other divisions, neither the position of the siphon nor the width of the perforation in the centre of the shell can be used to characterise the group.

Within these two divisions of the genus several developmental series can be easily distinguished, one of which has a very wide geological range.

The oldest species which I am inclined to unite with the *Tuberculati* is *Nautilus subtuberculatus*, Sandberger, out of rocks of devonian age. The characters of the group are, however, not yet well developed in this species, as the tubercles disappear in the older individuals, and an obtuse keel is present on the middle of the ventral part of the shell. The typical form of the species belonging to this group is only exhibited by *Naut. tuberculatus*, Sow., itself, and from it the group can be traced without interruption up to the top of the palæozoic formations. The species, which is most closely allied to the one described by Sowerby, is *Naut. tuberculatus*, Verneuil (non Sow.), the distinctness of which species from the true *tuberculatus*, has been recognised long since by Prof. Möller, without, however, his introducing a new name for it. It would be convenient to call this species NAUT. MÖLLERI, Waagen. Next comes *Naut. flemingi*, Koninck, which is the geologically oldest species of the *Tuberculatus* group occurring in the Salt-range. De Koninck's original, which I am in a position to refigure, thanks to the liberality of the Geological Society of London, in whose collection it has been preserved, comes from the middle region of the Productus-limestone. This is followed by *Naut. goliathus*, Waagen, which species I shall have to describe hereafter; it was found in the lower part of the upper division of the Productus-limestone. A species which is again very nearly allied to *Naut. mölleri*, but easily distinguishable by the more numerous tubercles, and which also very likely closely resembles young specimens of *Naut. goliathus*, is *Naut. multituberculatus*, Waagen. It is the most recent species of the group in the Salt-range, and was found in beds at the very top of the Productus-limestone formation. With this species the group of *Naut. subtuberculatus* seems to terminate, as no species, thoroughly allied to the group, has as yet been found in more recent formations.

Another series of forms which is very closely allied with the foregoing, but which can always be distinguished by the somewhat squarish transverse section of the whorls, whilst the foregoing group has this section always more or less triangular, is the one of which *Naut. tuberculatus*, Trantschold (non Sow.) must be considered as the geologically oldest form. The difference of this species from the true *N. tuberculatus*, Sow., is so obvious, that I think nobody will object when I introduce a new name for this form, and I propose to call it from its des-

criber NAUT. TRANTSCHOLDI, Waagen. This species was found in the upper carboniferous limestone of Miatchkowa. To it some forms in the Salt-range are most closely related. They form part of the fauna of the Upper Productus-limestone, and I shall describe them under the names of *Naut. transitorius*, Waagen, and *Naut. wynnei*, Waagen. The latter very naturally leads us to *Naut. dorso-armatus*, Abich, and *Naut. tuberculatis*, Abich, from Djoulfa on the Araxes, and these again furnish the connecting link with *Naut. pichleri*, Hauer, which is characteristic of the Muschelkalk formation of the Alps, and is on its part again intimately connected with several upper triassic species. Another branch, which also very likely takes its origin from the same series of forms, is that composed of *Nautilus hornesi*, Stache, *N. sebedinus*, St., and *N. crux*, St., out of the Bellerophon-limestones of the Alps, whilst *Naut. fugax*, Mojs., recalls again more vividly the form of the shell as it is exhibited by the older species, *N. trantscholdi*, *transitorius*, or *wynnei*.

A species which also very likely must be considered as forming part of the group of *Naut. trantscholdi*, but which is somewhat aberrant in its development, is *Naut. latissimus*, Waagen, out of the very top beds of the Productus-limestone formation of the Salt-range. To this species *Naut. talladii*, Mojs., out of the Alpine Muschelkalk seems to be rather nearly related.

With these forms, however, the number of species belonging to the *Tuberculati* is yet far from complete. A great many shells belonging to this group have been described from American localities, but all of them seem to belong to developmental series entirely different from those just pointed out among the European and Asiatic species. Only *Naut. occidentalis*, Schumard (non Hall) bears a close resemblance to *Naut. trantscholdi*, W., and might belong to the same developmental series.

As to the occurrence in time of the different forms mentioned above, it is absolutely impossible at present to indicate with any tolerable certainty the exact succession in time of species coming from different localities. The more minute stratigraphy of the beds in which these species occur is yet so far from being exactly known that indications in that direction bear only the character of very vague general parallelism, and thus an exact homotaxis of the upper palæozoic deposits has not yet been established. Only for the species occurring in the Salt-range the relative position can be positively affirmed.

The other division of the *Imperfect Nautili* which I have proposed above are the *Ophionei*. The number of species belonging to this division is far smaller than that belonging to the *Tuberculati*, but nevertheless the few forms hitherto discovered are of very great interest. A group of forms, which is very nearly allied to the *Ophionei*, is composed of those species which are more or less allied to *Naut. subsulcatus*, Phill., but I think the division here under consideration ought not to be so far extended as to comprise also these forms, and it will be much more practicable to create for the latter a separate division. In the extension I have in mind

to attribute to the division, the *Ophionei* take their origin from a species which I have collected in the lowest beds of the middle region of the Productus-limestone of the Salt-range, and which I shall call *Naut. ophioneus*, Waagen. In very near relation to this species is *Naut. connectens*, Waagen, from the highest beds of the middle Productus-limestone. It forms the connecting link with *Naut. convolutus*, Waagen, out of the upper region of the Productus-limestone. In these species a very marked tendency is observable, to close the perforation in the centre of the umbilicus and to produce more and more a rounded section of the whorls. This same tendency holds good also for the more recent species which belong to the same developmental series. There is in the first place to be mentioned *Naut. spitiensis*, Stol., out of the Himalayan Muschelkalk formation, which is distinct from *Naut. convolutus* by its still more closely coiled spiral and the more ventral or external position of its siphon. Stoliczka very reasonably points out the close resemblance of his species to *Naut. brevis*, Hauer, out of middle triassic beds of the Alps, and there is a great probability that this species and its relatives stand in close developmental connection with the Indian shells.

Of other than Indian species there are some which belong beyond doubt to the division of the *Ophionei*, but I cannot state if they possibly might be counted also with the developmental series of *Naut. ophioneus*. Such a form is *Naut. tulensis*, Barbot de Marny, out of the lower Mountain-limestone of the Government of Toula, *Naut. parallelus*, Abich, from the upper carboniferons beds of Djulfa on the Araxes, etc.

From what has been said on the foregoing pages, we see that the species of *Nautilus* occurring in the palæozoic beds of the Salt-range can be properly classified in the following manner :—

I. Section : Simplices.
   Naut. peregrinus, Waagen.

II. Section : Tuberculati.
   a. Group of Naut. subtuberculatus, Sandb.
      1. *Naut. flemingi*, Koninck.
      2. „ *goliathus*, Waagen.
      3. „ *multituberculatus*, Waagen.
   b. Group of Naut. trantscholdi, Waagen.
      1. *Naut. transitorius*, Waagen.
      2. „ *wynnei*, Waagen.
   c. Aberrant species.
      1. *Naut. latissimus*, Waagen.

III. Section : Ophionei.
   a. Group of Naut. ophioneus, Waagen.
      1. *Naut. ophioneus*, Waagen.
      2. „ *connectens*, Waagen.
      3. „ *convolutus*. Waagen.

Though there are three divisions of the *Nautili* present in the Salt-range, this represents but a very small fraction of the entire variety of forms included in the genus. Even if we compare only the *Nautili* occurring in the upper formations of the palæozoic series, we find that the variety of forms which they contain is generally far greater than that represented in the Salt-range strata. Principally two divisions of the genus are strongly developed in the carboniferous strata of Europe and America; these are the *Compressi* and the *Multicarinati*. The former, for which I am inclined to introduce the above name, comprise chiefly those forms which are united by M'Coy in his sub-genus *Discites*, whilst the type for the latter is represented by the species *Naut. multicarinatus*, Sow. It is a fact worthy of notice that these two divisions of the genus are altogether absent in the Salt-range, not a single one of them having as yet been detected there. On the other hand, the forms which are present in the Salt-range have mostly their chief development in higher strata, though the type commences partly in the devonian period. So also the *Tuberculati* are represented in the lower carboniferous limestone of England, etc., only by a few species; whilst in the upper carboniferous limestone of Russia, etc., there are about ten species, which on their part have again their nearest allies in dyas and trias of the Alps. Of the *Ophionei* this is less apparent, but the *Simplices*, which also have a representation in the Salt-range, are of a nearly exclusively mesozoic and tertiary distribution.

I.—Section: SIMPLICES.

1. Nautilus peregrinus, Waagen, n. sp. Pl. VI, fig. 3.

Though the only specimen of this species, which I possess for description, is in rather bad preservation, yet the general form of it is so remarkable that I think it expedient to notice it more in detail, and to propose a new name for it.

The general form of the shell is thick lenticular, with a broadly rounded external part. The umbilicus is very small and deep, surrounded by curved umbilical walls, which unite with the sides of the whorl without forming any edge. The concavity of the septa on the sides towards the mouth of the shell is rather shallow; and the sutures, where the septa unite with the external shell, are very nearly straight; they are very slightly curved backwards on the sides of the shell, and form a low arch towards the front on the external part of the whorl. The septa are not very numerous, about twelve or fourteen on each whorl, but it is difficult to count them accurately on the existing specimen. The position of the siphon is not well observable, but it seems to be within the outer third of the radial diameter of the septum, and as far as can be made out, it seems rather thick. The latter end of the last whorl in the specimen under consideration belongs to the body chamber. The specimen is, however, not full grown, as the last septa are not more closely arranged.

It is very difficult to give the exact measurements of the specimen, as it is obliquely compressed, whereby all dimensions are more or less altered from what they were originally. As far as can be made out, the specimen seems to have had the following dimensions:—

	mm.
Diameter of the shell	90
„ „ umbilicus	6
Height of the aperture from the umbilical suture	58
„ „ „ from the preceding whorl	? 37
„ „ preceding whorl from the umbilical suture	28
„ „ „ „ from the one following next	22
Distance of siphon in this whorl from the outer part of the preceding one	15
Thickness of the aperture	? 35
„ „ preceding whorl	25

Locality and geological position.—The only specimen of this species which is preserved in the Salt-range collection was found by myself in the thick compact limestones of the middle division of the Productus-limestone at Khúra.

Remarks.—This species is very remarkable on account of its near affinity to the mesozoic, chiefly jurassic, species of *Nautilus*. I do not know any *Nautilus* in palæozoic strata which would approach so nearly the mesozoic forms; either the umbilicus is larger, or the position of the siphon is exceptional, but if we compare, for instance *Naut. subinflatus*, Orb., or *Naut. intumescens*, W., with our species, the affinity is so great that the only difference rests in the more compressed form of our species. Already in the description of *N. intumescens* (Pal. Ind., Jur. Fauna of Kachh, Vol. I), I have pointed out that this species is most nearly allied to the living *Naut. pompilius*, L.; and there is no doubt that *N. peregrinus* must, like the species just mentioned, be put into the same division of the genus, the *Simplices* of Quenstedt. From the *Striati* of Quenstedt, our species, like the living *Naut. pompilius* or the allied jurassic species, differs by the absence of the somewhat flattened external part of the shell, which is characteristic of this latter division of *Nautili*.

II.—Section: TUBERCULATI.

a. Group of *NAUTILUS SUBTUBERCULATUS*, Sandberger.

1. Nautilus flemingianus, Koninck. Pl. III, fig. 2.

1863. *Nautilus flemingianus*, Koninck: Fossiles Paléozoiques de l'Inde, p. 7, pl. VIII, fig. 2.

The description of this species by de Koninck is so excellent that I have but very little to add to it.

The species is represented by a single fragment, which is, however, so well preserved that it is easy to recognise the peculiarities of the species from it.

The general form of the shell is thick disciform. The umbilicus is very wide, the whorls only touching each other. The whorls are broad, with a somewhat triangular section, the largest transverse diameter lying near the outer part of the

whorl. The cast is provided with a very characteristic ornamentation, which, on the one hand, proves the affinity of the species to the group of *Naut. subtuberculatus*, Sandb., on the other, however, it also furnishes distinctive characters whereby the species is easily separated from the allied forms.

The first two or three whorls, up to a diameter of the shell of 55 mm., are perfectly smooth. The whorls are depressed, about as broad as high, and the transverse section of them is rather more squarish than triangular. When the shell grows larger slight protuberances begin to appear near the outer margin of the whorls; they are low, thick and elongated so as to extend towards the umbilical margin. With the progressing increase of the shell these protuberances increase in height, which is greatest near the outer margin of the whorl. As far as I am able to judge, there seem to have been about eighteen of these protuberances on the last whorl, each alternate air-chamber bearing one on each side. The external or ventral part of the shell is broad and depressed, but not flat, and is perfectly smooth, without ornamentation.

The septa are very numerous. They show a very slight lobe on each side and on the external part of the whorl, and a very low rounded saddle on both external margins and on the umbilical margins of the whorl. Their number is not equal throughout the whole extent of the shell. If we measure the breadth of each whorl and take the same distance on the side of the whorl, we find, that on the first whorl, which is distinctly visible in the fragment, five septa are comprised within this distance, on the second there are six and on the third eight, whilst at the same time the breadth of each whorl remains unchanged, equal its height. It is very difficult to judge how many septa there may have been in each whorl; there may have been about thirty-six to thirty-eight on the last one, about thirty to thirty-three on the preceding, and about eighteen to twenty on the innermost whorl. There are no means to ascertain how large the perforation in the centre of the umbilicus may have been.

The position of the siphon seems to be as indicated by de Koninck, that is, in the outer third of the height of the whorl, but it is so very indistinct that I cannot say anything positive about it.

The dimensions of the shell seem to have been the following :—

	mm.
Diameter of the shell about	173
„ „ umbilicus about	70
Height of the aperture from the umbilical suture	64
„ „ „ top of preceding whorl	61
„ preceding whorl from the umbilical suture	33
„ „ „ top of innermost whorl	31
Thickness of aperture	63
„ preceding whorl	31

Locality and geological position.—The only specimen of this species which has been found up to the present was collected by Dr. Fleming at Músakheyl in

a grey compact limestone, which beyond any doubt belongs to the middle region of the Productus-limestone, as no similar rock occurs there in any other division of that formation. We therefore can most positively assert, that *Naut. flemingianus* belongs to the fauna of the middle Productus-limestone (division No. 2 of the list, page 8).

Remarks.—Though *Naut. flemingianus* bears a certain resemblance to *Naut. tuberculatus*, Sow., yet it is not difficult to distinguish the two species. Already M. de Koninck has pointed out the chief differences, and there is but little to be added to his observations. The form of the tubercles, their position on alternate air chambers, and the much more numerous septa in our species, are sufficiently distinctive characters to separate it from the English shell as described by Phillips and Sowerby. Somewhat more closely allied is *Naut. mölleri*, W., but this species also has its tubercles differently shaped and less numerous, and besides this, the septa are more numerous in the Russian form than even in the Indian species. If we compare specimens of equal size, we find that at a diameter of the shell of about 30 mm. there are about thirty-five septa on the last whorl in *Naut. mölleri*, whilst in *Naut. flemingianus* there are at the diameter mentioned not more than about twenty septa on the last whorl.

Of other species of the *Tuberculati* none is so closely allied as to require special notice. I might mention *Naut. tuberosus*, M'Coy, *Naut. ponderosus*, Meek and H., and several species described in Worthen's Illinois reports; but the resemblance of all these to deKoninck's species is so superficial that it seems not necessary to indicate the differences in detail.

2. Nautilus goliathus, Waagen, n. sp. Pl. IV.

This species is represented by a single complete specimen and a small fragment but as its form is very characteristic and its geological position well ascertained, it can well be described under a proper specific designation.

The general form of the shell is that of a very thick disk. The umbilicus is very deep, but not very wide; the whorls are very thick and inflated with an extremely broad flattened external part. The transverse section of the whorls is broad trapezoidal, the broadest diameter being near the outer edge of the whorl. The lateral parts of the whorls unite with the external part in a rounded edge, which is ornamented with a row of thick elongated rib-like tubercles extending halfway down the height of the whorl. There are about fifteen of these tubercles on the specimen of a diameter of 168 mm. The lateral parts of the whorls slope down from the external edge regularly to the umbilical suture, only showing a slight curve, without forming any umbilical edge or a distinct umbilical wall.

The septa of this species are slightly curved like those of the preceding one, but they are much less numerous. Besides this there is no relation between the

air chambers and the tubercles, as is the case in *Naut. flemingianus*. The specimen I have got for description is not sufficiently well preserved to count the number of septa on each whorl, but there may have been about thirty-two on the last circuit.

The position of the siphon could not be ascertained.

The dimensions are somewhat difficult to take, as the specimen has been obliquely compressed, but they seem to have been as follows:—

	mm.
Diameter of the shell	169
„ „ „ umbilicus	53
Height of the aperture from the umbilical suture	76
„ „ „ „ „ „ preceding whorl	? 60
Thickness of the aperture	97

Locality and geological position.—The only complete specimen of this species in the Salt-range collection was found by myself in the lowest beds of the upper division of the Productus-limestone, not far from the Serai at Katwahi, in the bed of a stream, not loose on the ground, but in the rock *in situ*. A small fragment, which also very likely belongs to this species, was collected by Mr. Wynne at Jalár among the debris. From its preservation it is probable that it also came from the upper region of the Productus-limestone.

Remarks.—*Naut. goliathus* is most nearly allied to the species described by de Koninck under the name of *Naut. flemingianus*, as already noticed more in detail. However, in comparing the figures given on Pls. III and IV, one will easily notice the differences which exist between the two species, and which consist in the greater thickness of the whorls, the different arrangement of the septa, and the comparatively smaller umbilicus of *Naut. goliathus*. From *Naut. tuberculatus*, Sow., and *Naut. mölleri*, W., our species is also easily distinguishable by the much smaller umbilicus and the greater thickness of the whorls. Of foreign species only *Naut.* (*Endolobus*) *spectabilis*, Meek and Worthen, bears a certain resemblance, but the transverse section of the whorls in this species is quite different from that in the Indian form.

3. Nautilus multituberculatus, Waagen, n. sp. Pl. VI, fig. 5.

Among all the species of *Nautilus* from the Salt-range this one has the greatest resemblance to *Naut. tuberculatus*, Sow.; but as there are nevertheless some striking differences, a new name for this form cannot be avoided.

The general form of the shell is thick disciform, with a very wide and rather deep umbilicus. The transverse section of the whorls is triangular, the external part being very broad and depressed, and forming an obtuse edge with the lateral part of the whorls, which is provided with a row of thick radially elongated tubercles. The lateral parts of the whorls slope regularly with a slight curve to the umbilical suture, without forming any umbilical edge or an umbilical wall. The

tubercles are very numerous, but as the entire whorl is not preserved in the specimen I have got for description, I am unable to state exactly how many there may have been on one circuit. As far as I can judge, however, there may have been about twenty-three. The form of the septa is not well observable, as the specimen is covered with its shell; for the same reason I am unable to state how many of them there may have been on one circuit. So much, however, can be observed, that the tubercles are not located on alternate air chambers. The siphon is rather narrow and pierces the septum exactly in its centre.

The shell seems to be entirely smooth, only with the lens are very fine lines of growth observable, the direction of which can, however, not be followed. If we complete the outlines of the shell as indicated by the existing fragment, forming only the inner volutions of a larger shell, the entire specimen seems to have had the following dimensions:—

	mm.
Diameter of the shell (about)	43
„ „ „ umbilicus (about)	17
Height of the aperture from the umbilical suture	15
„ „ „ „ „ „ preceding whorl	13·5
Thickness of the aperture	24

Locality and geological position.—The only fragment of this species which has been found up to the present was collected by myself near Amb, in the very highest beds of the Productus-limestone, just below the Ceratite formation.

Remarks.—The form which most resembles the present species is *Naut. mölleri*, Waagen. The most striking difference from this shell, however, consists in the number of tubercles, which in *Naut. mölleri*, in a specimen nearly equal in size to the one described here, is not more than about fourteen, whilst in our species this number is about twenty-three. Of other species, chiefly *Naut. goliathus*, W., must be compared; but it is difficult to state exactly the affinities or differences of the two shells, as the sizes of the existing specimens are so very unequal. As far as I am able to judge, *Naut. multituberculatus* seems to differ from the species described above by more numerous tubercles, and by whorls which are comparatively broader.

It is a fact, which requires more special notice, that the species now under consideration reproduces again so closely the form of *Naut. mölleri*, whilst it seems less allied to the two species described before it, *Naut. flemingianus* and *Naut. goliathus*. This strange fact seems either attributable to atavism, or else I have possibly mixed up two different developmental series, one of which might be composed of *Naut. subtuberculatus*. Sandb., *Naut. tuberculatus*, Sow., *Naut. mölleri*, W., and *Naut. multituberculatus*, W., whilst the other would be represented by the two species *Naut. flemingianus* and *Naut. goliathus*. It is very difficult to decide which of the two interpretations of the facts will be the correct one, as the correlations of the different beds within the newer palæozoic formations is as yet so little known that it is at present impossible to indicate which of the two different

kinds of arrangement of the species will show the real succession in time of the different forms. Certainly, if there are two different developmental series included in my group of *Naut. subtuberculatus*, Sandb., they are very closely allied to each other, and there is but very little doubt that the one has taken its origin from the other; but then it is not possible to indicate the exact time when the one has been separated from the other, as the one which would be characterised by *Naut. flemingianus* is already well developed in this species, without geologically older connecting species being known.

b. Group of *NAUTILUS TRANTSCHOLDI*, Waagen.

1. Nautilus transitorius, Waagen, n. sp. Pl. V, fig. 1; Pl. VI, fig. 4.

The general form of this species is very different according to the age of the shell.

The whole shell appears thick disciform, with a wide and rather shallow umbilicus. The transverse section of the whorls is somewhat squarish, the outer or ventral part of the shell being flat with a shallow depression in the middle. The lateral parts of the whorls are perpendicular, and form a distinct angle with the external part. The umbilicus is surrounded by a distinct umbilical wall, which forms a more or less distinct edge where it unites with the lateral parts of the whorls.

In the young shell the first circuit has a diameter of about 17 mm., being pierced in the middle by a central aperture of about 5 or 6 mm. in diameter. The commencement of the shell is quite smooth (the entire form of the "calotte" not being well observable) and very depressed, the transverse section about twice as broad as high; but already towards the end of the first circuit the ornamentation of the shell begins to appear. This consists of a prominent crest along the umbilical edge and of low folds on the outer margin of the whorl, where the lateral and external parts of the shell unite. As the shell grows larger these folds increase considerably in height, and extend more and more towards the crest which surrounds the umbilicus. There may have been about fifteen of these folds on the third volution, how many there may have been on the second is not observable. On all these inner whorls the external part of the shell seems to have been entirely smooth, without marked depression in the middle.

On the last whorl the sculpture changes considerably. Already towards the end of the third volution the crest on the umbilical margin thickens at certain intervals, and generally one of these nodular thickenings corresponds to two of those folds on the lateral parts of the whorl. On the last whorl now this crest is entirely resolved into single high knobs along the umbilical edge, and no proper crest remains. These knobs unite with alternate high thick ribs, which come from the external margin of the whorl, and are highest on that margin. Between these there are

other ribs equally high on the outer margin of the whorl, but which disappear gradually towards the umbilical edge. The whole system of sculpture becomes less prominent towards the mouth of the shell.

The strong ribs which cover the lateral parts of the last whorl extend on this whorl in a somewhat retrograde direction to the external or ventral part of the shell, up to near the middle of it, and terminate there as two very low longitudinal ridges which border a tolerably broad medial depression on both sides.

It is very difficult to observe what form the sutures of the septa may have possessed, as the whole specimen is covered with its shell, but it seems that there were sinuosities both on the sides and on the external part of the whorl.

I am not able to indicate anything as to the number of septa in one whorl, but the siphon is clearly observable on one of the septa. It is very narrow, and in its position nearer the internal than the external side of the whorl.

The dimensions of one of the specimens are as follows:—

	mm.
Diameter of the shell (about)	130
„ of the umbilicus (about)	53
Height of the aperture from the umbilical suture	53
„ „ from the preceding whorl	48
Thickness of the aperture	63

Locality and geological position.—There are two specimens of this species in the Salt-range collection; one of them was collected by myself on the road from Vurcha to Uchâli, in the lower beds of the upper division of the Productus-limestone; the other was found by Mr. Wynne at Khund Ghât, also in the upper division of the Productus-limestone; the species seems thus to be restricted to that group of the formation.

Remarks.—This species is very remarkable as forming the transitional link between *Naut. trantscholdi* and a series of forms which shows its largest development only in lower mesozoic strata. Whilst in *Naut. trantscholdi*, W., the form of the shell, as is exhibited in young specimens of *Naut. transitorius*, a high crest surrounding the umbilical wall, and tuberculated folds along the outer margin of the whorl, remain up to the very mouth of the shell, in *Naut. transitorius* this kind of ornamentation is restricted to the inner volutions, whereas on the last whorl it is resolved into a number of thick separated folds, as is the case in the geologically younger forms.

As a species, *Naut. transitorius* is not very difficult to distinguish from the allied forms. In all stages of development it is distinct from *Naut. trantscholdi*, W., by the absence of the rows of small tubercles on both sides of the median depression along the external part of the shell. Of other species *Naut. tubercularis*, Abich, must be compared; but in this species not only the crest or the tubercles along the umbilical edge are also absent, but the transverse section of the whorls is entirely different. Very few other species can be compared, but even if they bear a certain resemblance a distinction is still not difficult.

2. NAUTILUS WYNNEI, Waagen, n. sp. Pl. III, fig. 1.

This species, though very nearly allied to the preceding one, can be very well distinguished from it by the peculiarities of its ornamentation.

The general form of the shell is very thick disciform, with a wide and tolerably shallow umbilicus. The section of the whorls is transversely rectangular. The external part of the shell is strongly depressed with an excavation in the middle, which is bordered on both sides by a distinct low and not very sharp ridge. On the outer edge of the whorl there is a row of thick prominent tubercles, from which faint ribs extend towards the median depression on the external part of the shell, and much stronger ones on the lateral parts of the whorl towards the umbilical edge. The lateral parts of the whorls are very little rounded, the umbilical edge is not very sharp and without crest or ridge. The umbilicus is surrounded by a high umbilical wall. The number of tubercles is about fifteen or sixteen on the last whorl, and they seem to be comparatively more numerous towards the end of it than they are at the beginning.

There is no means of ascertaining the changes the ornamentation of the shell may have undergone during its growth, as the inner volutions of the shell are not preserved in the specimen I have for description.

The septa are very numerous, but this seems to be partly due to the specimen being full grown, as the last of the septa are much more closely arranged than those at the beginning of the last whorl. The sutural lines of the septa are very strongly concave in front on both sides of the whorl and also on the external part, where they form a shallow somewhat angular lobe, whilst they exhibit a convexity on both the external margins and on the umbilical edges of the whorl.

The siphon is exactly central and very likely nummuloid, of which fact, however, I am not quite certain. In a section in the middle of an air chamber between two septa at about half the length of the last whorl the siphon is not less than 6 mm. thick. It is not probable that the hole by which the siphon pierces the septum has got equal dimensions; it is probably narrower, which necessarily would make the siphon appear nummuloid. Within the siphon no radial lamellæ can be observed.

The dimensions of the only specimen of this species are as follows:—

	mm.
Diameter of the shell	120
„ of the umbilicus	49
Height of the aperture from the umbilical suture	44
„ „ „ from the preceding whorl	38
Thickness of the aperture	58

The specimen is preserved up to the very last air chamber, but the body chamber has been entirely broken away. It is quite full grown.

Locality and geological position.—The only specimen of this species which is preserved in the Salt-range collection was found by Mr. Wynne at Khund Ghât on the road from Shahpur to Sukesar mountain. From great numbers of other fossils

which Mr. Wynne has collected there together with the Cephalopoda, it is evident that he has taken them from the upper division of the Productus-limestone. Khund Ghât is one of the richest fossil localities of the upper Productus-limestone.

Remarks.—It is not difficult to distinguish this species from some allied forms. First it differs from *Naut. transitorius*, W., by the absence of a crest along the umbilical edge, or the tubercles which replace it on the last whorl of that species. The ribs are not in pairs, and the excavation on the external part of the shell is narrower and more distinct. Of other species, chiefly *Naut. dorsoarmatus*, Abich, is rather nearly allied, and indeed the inner volutions of our species must have been very like Abich's species from Djulfa. But in the latter the external part of the shell is very little excavated, and the tubercles are more pointed and prominent; the septa are less concave on the lateral as well as on the external parts of the whorl. The middle triassic *Naut. pichleri*, Hau., is easily distinguishable by the absence of an excavation on the external part of the whorl and more numerous tubercles. A more close affinity exists between our species and *Naut. hörnesi*, Stache. The system of sculpture is entirely identical in both species, only the Alpine species has a greater number of tubercles and the lateral parts of the whorl more smooth. In all other respects the similarity is very great.

Naut. wynnei thus appears as a thoroughly intermediate form between the older species of the *Tuberculati* and those triassic forms which hitherto could only with some doubt be considered as belonging to that division of the genus.

c. ABERRANT SPECIES.

1. NAUTILUS LATISSIMUS, Waagen, n. sp. Pl. VI, fig. 1.

This species is remarkable on account of its following a nearly opposite development to that which I have described in *Naut. transitorius*. There is but little doubt that it has taken its origin from the latter species, but its development is of such a kind as to suggest that this species is due to a kind of "atavism."

The general form of the shell is nearly globular, with a not very wide, but extremely deep, umbilicus. The transverse section of the whorls is rather different in different stages of growth, but there is always a sharp crest on the umbilical edge, whence a very high perpendicular or sloping umbilical wall extends towards the umbilical suture. I have not any specimen in which I could observe the first stages of growth, nor can I state how large the perforation in the centre of the shell may have been. The smallest size of the shell which I am able to describe measures already 23 mm. in diameter. At that size the whorls are very depressed, the external part of the shell rounded and slightly prominent, the lateral parts very low, passing gradually into the external part, and covered with numerous broad rounded folds. The umbilical edge is provided with a prominent ridge, which directly passes into the high perpendicular umbilical wall.

At a diameter of about 55 mm. the form of the shell is somewhat changed, the external part is less prominent, more depressed; the lateral parts are higher, but yet without forming any distinct external margin of the whorl. The folds on both sides of the whorl become gradually lower and broader, but the umbilical edge is still provided with a distinct longitudinal ridge, and the umbilical wall is still perfectly perpendicular.

Again at a diameter of 85 mm. the form of the shell is once more changed. The external part of the shell is very nearly flat, only very little prominent. The transverse section of the whorls is no longer approximately semicircular as in younger specimens, but more or less rectangular, the lateral parts of the whorl forming an obtuse external edge, where they unite with the external part. The sides of the whorl are perfectly smooth without any trace of folds or any other ornamentation. The ridge on the umbilical edge has very nearly disappeared, only a sharp umbilical edge has remained. The umbilical wall is as high as ever, only no longer perpendicular, but sloping.

With this form the last stage of development seems to be attained. I cannot indicate, however, how large the species may have grown; but in all the stages of growth the thickness of the whorls in comparison to their height is excessive, so that they are about twice as broad as high.

The septa are not very numerous, but none of the specimens is sufficiently well preserved to count how many there were in one circuit. Their distance from each other in the external part of the shell is exactly the fifth part of the transverse diameter of the whorl. The sutures of the septa are very little curved, only slightly sinuous as well on the lateral as on the external part of the whorl.

The siphon is not visible on any of the specimens.

The dimensions of the two specimens of this species in the Salt-range collection, No. 1 being from Virgal, No. 2 from Khund Ghât, are as follows:—

	I. mm.	II. mm.
Diameter of the shell	62	85
„ of the umbilicus at the umbilical suture	17	? 23
„ „ „ „ edge	23	34
Height of the aperture from the umbilical suture	35	44
„ „ from the preceding whorl	28	? 36
Thickness of the aperture	54	? 68

Locality and geological position.—There are two specimens of this species preserved in the Salt-range collection. One of them was collected by myself at Virgal, in the uppermost beds of the upper division of the Productus-limestone (band No. 1 of my section); the other was found by Mr. Wynne at Khund Ghât, also in the upper division of the Productus-limestone.

Remarks.—It is not in the least difficult to distinguish this species from those previously described. The only one which can be compared with *Naut. latissimus* is *Naut. transitorius*, W. The full grown shells of both species are, however, as

dissimilar as possible, the one being smooth, the other provided with strong ribs and tubercles, only young specimens are somewhat similar. The whorls of *Naut. latissimus* are, however, in all stages of growth, more depressed and broader than those of *Naut. transitorius*.

The full grown form of *Naut. latissimus* is very remarkable for a certain similarity to those species of *Nautilus* which have been considered by Quenstedt as forming his group of the *Moniliferi*. If we compare specimens of *Naut. bidorsatus*, Schlotheim, we find that the general form of the shell agrees pretty well with that of the full-grown shell of *Naut. latissimus*, only the whorls are broader and the outer edge of the whorls is less angular in the latter than in Schlotheim's species. The directly connecting links between the two species, however, are absent, and thus it cannot be ascertained whether we have to deal here really with the ancestor of those triassic forms or not, but the similarity must not be lost sight of.

A resemblance which is yet more striking exists between *Naut. latissimus* and *Naut. palladii*, Mojs., out of the Muschelkalk formation of the Alps. The general form of the shell in both species is nearly identical, but, whilst in the former the sculpture disappears only in the full-grown shell, in the latter the shell is smooth from its commencement. There is, however, a great probability of the developmental connection of the two species.

III.—Section: OPHIONEI.

a. Group of *NAUTILUS OPHIONEUS*, Waagen.

1. Nautilus ophioneus, Waagen, n. sp. Pl. V, fig. 2.

The general form of the shell is that of a flat disc, with a very large perforation in the centre; the umbilicus is very wide and shallow, the whorls compressed, much higher than broad; the external part of the shell quite rounded, without any edges or ridge.

The character which is most striking in this species is the diameter of the perforation in the centre of the shell. The commencement of the shell is cylindroidal, and a fragment of the first whorl might easily pass as a *Cyrtoceras*. The "calotte" could not be well observed, as the whole fossil consists of calcspar, and in cleaning the specimen for description the innermost part of the shell was slowly crumbling away. Only the latter part of the first half of the first whorl has remained tolerably intact; but a drawing could be made before the whole was destroyed. The transverse section of the first whorl, up to the commencement of the second, is perfectly rounded, circular in the beginning and slowly increasing in height as the second circuit is approached. The shell is perfectly smooth without any ornamentation. The first volution of the shell has not less than 60 mm. in diameter. As the first whorl is completed and the involution of the whorls commences with the second whorl, the transverse section completely changes, an

umbilical edge appears, and distinct low umbilical walls are developed. From the second whorl the increase of the shell regularly progresses. The umbilical walls become gradually more and more sloping, and the edge which surrounded the umbilicus, less distinct. The external part of the shell is always perfctly rounded, without any depression or edges.

The septa are always very numerous, but their distance from each other varies according to the age of the shell. In the first whorl their distance is about equal to half the height of the whorl, in the second this distance is about one-third of the height of the whorl, and in the third it is only about one-fifth of this height, wherefrom it appears that the septa get more and more numerous as the shell increases in size.

The sutures of the septa are very strongly sinuous on the sides of the whorl, but go straight over the external part of the shell. On the inner whorls they are less sinuous than on the outer.

The siphon is tolerably wide and not quite central, but situated somewhat nearer the inner than the outer side of the whorl.

The dimensions of the single existing specimen are as follows:—

	mm.
Diameter of the shell (about)	157
„ „ „ umbilicus (about)	75
Height of the aperture from the umbilical suture	51
„ „ „ „ from the preceding whorl	48
Thickness of the aperture	36
Height of the second whorl from the umbilical suture	18
„ „ „ „ „ from the preceding whorl	17
Thickness of the second whorl	16
Height of the innermost whorl	8
Thickness of the innermost whorl	8

The spiral is not quite regular during the different stages of growth of the shell, but on an average the "Quotient" of the spiral seems to be $p = 2{\cdot}7$. It is, however, very difficult to make reliable observations in this respect, if it is not possible to take the measurements from a median section of the shell; but as the spiral of this species is decidedly different from that of the next following two species, I thought it expedient to ascertain its quotient, though only approximately, in order to have one more point of comparison.

Locality and geological position.—Only one fragmentary specimen of this species has been collected by myself in the mountains east of Katwáhi. I did not find it in the rock *in situ*, but among the debris, but the place where it was procured was such that the beds it came from were not easily to be mistaken. It appertained originally either to the very lowest beds of the compact limestone composing the middle region of the Productus-limestone, or to the highest beds of the lower division of the same formation. The character of the rock in which the specimen is contained makes it appear, however, more likely that the former is

the case, and that *Naut. ophioneus* belongs to the lowest beds of the middle division of the Productus-limestone.

Remarks.—The general form of the species under consideration is so very characteristic that it is not difficult to distinguish it from other allied forms. The species which seems to be most nearly allied to the one just described is *Naut convergens*, Abich; the differences consist in a slight excavation on both sides of the shell along its external margin, a slightly depressed external part of the shell, and septa which are (equal heights of the whorls of both species being compared) only the fourth part of the height of the whorl distant from each other in the latter species. *Nautilus parallelus*, Abich, which also bears some resemblance, has its whorls less high and more rectangular than our species, and the sutural lines of the septa are sinuous on the external part of the whorl, whilst they are straight in that position in *Naut. ophioneus*.

The whole group of the *Compressi* is also more or less allied to *Naut. ophioneus*, but the characteristic longitudinal edges, which are to be found in the species of this group either along the external or the internal margins of the whorls, are sufficient to distinguish all these species from the one here described.

2. Nautilus connectens, Waagen, n. sp.

There are two fragmentary specimens of a *Nautilus* in the Salt-range collection which indicate a species of very similar character to the one just described, but having some peculiarities which most decidedly establish a distinction between the two forms, and which I consider sufficient for the definition of a new species.

The general form of the shell is flat disciform, with compressed whorls and a very wide, shallow umbilicus. The transverse section of the whorls is an elongated oval, without umbilical or external edges. However, the form of the whorls changes somewhat according to the age of the shell. The perforation in the centre of the umbilicus is not very large, only about 12 mm. in diameter.

As far as it can be made out in the specimen, which is not very well preserved, the shell seems to commence with a broad, rounded "calotte," already 5 mm. broad. The first whorl is compressed, with an elliptical transverse section. Only when the involution of the whorls begins, with the commencement of the second whorl, a low, somewhat excavated umbilical wall is formed, which unites with the sides of the whorl in forming an obtuse umbilical edge. Already in the third whorl this umbilical wall as well as the edge are lost again entirely, and the elongated oval transverse section of the whorl is established as mentioned above.

The whole shell seems to have got four whorls. The larger of the two fragmentary specimens consists of the body chamber of a large individual, and this seems to have constituted the latter half of the fourth whorl. This body chamber is interesting, because it shows towards its aperture a slight depression of the external part of the shell.

The septa, which are only visible on one small portion, as both the specimens are entirely covered with their shell, seem to be less sinuous than in *Naut. ophioneus*, but their relative number seems to have been equal to that in the species mentioned.

The position of the siphon is not visible in any of the specimens.

The dimensions I am only able to indicate very approximately, as the specimens are too much broken to allow of proper measurements to be taken. The measurements of the larger of the two specimens seem to have been as follows:—

	mm.
Diameter of the shell	? 164
„ of the umbilicus	? 73
Height of the aperture from the umbilical suture	53
„ „ „ from the preceding whorl	? 49
Thickness of the aperture	34

It is to be remarked that the greatest thickness of the whorls lies, not near the umbilicus, but on the middle of the sides of the whorls.

The spiral of this species is not equal to that of the preceding one, but it is very difficult to construct it exactly from the fragments at my disposal. As far as I can make it out, the "Quotient" seems to be somewhere near 2·5; but seems to decrease in the earlier stages of growth of the shell.

Locality and geological position.—The two fragmentary specimens in the Salt-range collection were found by myself at a locality west of Khúra, in beds situated at the limits between the middle and the upper divisions of the Productus-limestone, but which very likely must yet be counted with the former. This species, therefore, is decidedly more recent than the one described above under the name of *Naut. ophioneus*, which has been stated to occur at the limit between the lower and the middle division of the same formation.

Remarks.—This species is not very difficult to discern from the one nearest allied to it, *Naut. ophioneus*, W. The distinctive characters consist in a more rounded transverse section of the whorls in *Naut. connectens*, the greatest transverse diameter being situated on the middle of the sides of the whorls, whilst in *Naut. ophioneus* its position is near the obtuse umbilical margin, in a more closely coiled spiral, and in a much smaller perforation in the centre of the shell.

According to the figure, *Naut. subsulcatus*, Trantsch. (non Phill.) seems also to be rather similar to our species, but the more angular external part of the shell, and a still smaller central perforation in the Russian form, are sufficient to distinguish the species. *Naut. leveilleanus*, Koninck, which also seems to be rather closely allied, has a comparatively smaller umbilicus, and less compressed whorls; besides this, the ornamentation characteristic of Koninck's species is absent in *Naut. connectens*.

Nautilus convergens, Abich, differs from our species by its much narrower external part of the shell, by which peculiarity a transverse section is produced, which resembles more that of *Naut. ophioneus* than that of the present species. Also *Naut. parallelus*, Abich, bears a certain resemblance to the species here under consideration, but its whorls are thicker in comparison to their height, the external

part more angular, and the sutural line of the septa excavated on the external part of the shell. *Naut. complanatus*, Sow., with which *N. parallelus* is compared, bears only a very slight resemblance to the Indian species.

On the whole, *Naut. connectens* is a well distinguishable species, which is thoroughly intermediate between *Naut. ophioneus*, W., and the following species, and which must be considered as in developmental connection with these two forms.

3. Nautilus convolutus, Waagen, n. sp. Pl. VI, fig. 2.

This species is very nearly allied to the two preceding ones, but there are some prominent characters which make a distinction not very difficult.

The general form of the shell is, as in the preceding species, flat disciform, with a wide and shallow umbilicus. The whorls are perfectly rounded without edges or ridges, the external part of the shell is not depressed.

The only specimen I have for description is not sufficiently well preserved to observe all stages of growth; thus I am not able to indicate exactly how large the perforation of the shell in the centre of the umbilicus may have been, nor is anything to be seen of the "calotte," or first whorl of the shell. The diameter of the first circuit of the shell seems to have been about 22 to 30 mm., and in consequence of this the diameter of the perforation was very likely not more than about 12 mm. At a diameter of the shell of 30 mm. the latter end of the last whorl does not yet bear any impression on its internal part, caused by the commencing involution of the whorls, and thus the second circuit of the shell has not yet commenced at that diameter. But very soon after this the involution begins. The transverse section of the whorl is, however, not subject to any change with the beginning of the second whorl, as is the case in the two preceding species. No umbilical edge or wall is formed, but the lateral parts of the shell are equally rounded, from the umbilical suture up to the external region of the whorl. The whorls increase rather rapidly in height, are little compressed, not much higher than broad.

The septa are very numerous, about the fifth part of the height of the whorl distant from each other. The sutural line of the septa is not very deeply excavated on the sides of the whorl, and slightly convex on the external part.

The siphon is very narrow, not quite central, but very slightly shifted towards the internal part of the whorl.

The dimensions of the specimen seem to have been as follows:—

	mm.
Diameter of the shell (about)	85
„ „ umbilicus	35
Height of the aperture from the umbilical suture	31
„ „ „ from the preceding whorl	30
Thickness of the aperture	26
Height of the preceding whorl	13
Thickness of the preceding whorl	12

The spiral of this shell is more closely coiled than that of the two preceding species; but, as in those, it is extremely difficult to get exact measurements for the proper definition of the spiral, as far as can be made out, the quotient seems to be $p=2{\cdot}3$.

Locality and geological position.—The only specimen of this species was collected by Mr. Wynne at Khund Ghât, and from the fossils he found with it, it is apparent that the whole came from the upper division of the Productus-limestone.

Remarks.—This species is easily distinguishable from the two previously described by the absence of an umbilical edge in the young shell, by a more closely coiled spiral, and by whorls which are much thicker in comparison to their height. Of other species *Naut. tulensis*, Barbot de Marny, is most nearly allied. The general form of the shell, the outline of the whorls, and the sutures of the septa, are very nearly identical, but the diameter of the umbilicus is comparatively much smaller, and the involution of the whorls by far more considerable. These differences are quite sufficient to distinguish the two shells specifically. From the figure it would appear that *Naut. tulensis* should be considered as belonging to the same developmental series as *Naut. convolutus*, and if this were the case, the former, from its general shape, would have to be considered the most recent member in the series, but as it appears from the description, *Naut. tulensis* has been found together with *Productus giganteus*, Sow., and would thus belong to the fauna of the lower carboniferous limestone of Russia. It is more than improbable that the Salt-range beds are lower down in the geological series than the lower carboniferous limestone of Russia, and *Naut. tulensis* therefore must belong to another developmental series than that to which *Naut. convolutus* belongs.

It is not difficult to find out what root *Naut. tulensis* may have sprung from. From the carboniferous limestone of Visé a *Nautilus* has been described by de Koninck under the name of *Naut. leveilleanus*, which bears a great resemblance to the Indian species just described. The differences consist in a flattened external part of the shell, a less rapid increase of the height of the whorls, and a yet smaller involution of the shell in *Naut. leveilleanus*, Kon., in comparison with *Naut. convolutus*. Now, the former species must very likely be considered as belonging to the same series of forms as *Naut. tulensis*, which series would then in a very remarkable way undergo similar changes to those we have already indicated as occurring in the series of *Naut. ophioneus*, a tendency prevailing to produce more and more a roundish section of the whorls and a more closely coiled spiral.

A species which is also very closely related to *Naut. convolutus*, as well as to *Naut. tulensis*, is *Naut. spitiensis*, Stol. It has been found in beds in the Himalaya which with every probability represent there the formation of the Muschelkalk, and indicates very fairly there the continuation of the developmental series of *Naut. ophioneus*. Its spiral is even more closely coiled than *Naut. convolutus*, and the transverse section of the whorls is perfectly oval. A new character, however, appears in this species; this consists in the siphon being shifted towards the ventral part

of the shell. This character is yet more strongly developed in the upper triassic species of the Alps, as in *Naut. brevis*, Hau., *Naut. evolutus*, Mojs., *Naut. eugyrus*, Mojs., etc., which very likely must be considered as the descendants of *Naut. spitiensis*.

From Abich's species of *Nautilus*, the Indian form is distinguishable by the same characters as those by which it differs from *Naut. ophioneus*, W., or *Naut. connectens*, W.

Genus: GYROCERAS, Koninck.

Stranger even than the occurrence of *Orthoceratites* together with true *Ammonites* in the triassic beds of the Alps, is the occurrence of a species of *Gyroceras* with *Ammonites* in the Salt-range strata. *Gyroceras* has hitherto been considered as exclusively a palæozoic genus, as the true *Ammonites* were taken to be exclusively mesozoic, and up to the present, according to Barrande's tables, even no permian species of the genus has been known.

It is therefore only natural that I regarded with great distrust the fragment of a *Gyroceras* which I found in the Salt-range; but after much consideration I cannot but consider the fragment as in reality belonging to that genus.

There are only two cases possible, either the specimen is a fragment of an *Euomphalus*, or it is a *Gyroceras*. For the former the shell is too thin, the septa too regular; besides this a siphon seems to be present, though this is not very distinct, but all these characters combined make it quite improbable that we should have to deal here with an *Euomphalus*, but all of them are in favor of the opinion, that the fragment should be considered as a *Gyroceras*.

Up to the present, according to Barrande's tables, thirty-nine species of the genus have been described, to which several have been added in Bigsby's Thesaurus. The genus commences in the upper silurian strata, continues through the devonian period, and is represented in carboniferous times by a few species in Europe and America. All of these species are more or less strongly ornamented, partly by longitudinal ridges, as the species described by Koninck, partly by tubercles, as all those forms more or less allied to *Gyroceras ornatum*, Gdf. According to these two different systems of ornamentation, we are able to divide the genus into two large groups, which are, however, not thoroughly distinct from each other, being connected together by many intermediate forms.

The materials at my disposal are not sufficient to indicate anything more definite about the grouping of the species within the genus, or to point out one or the other developmental series; the only species from the Salt-range which I shall have to describe belongs to that group of forms to which *Gyr. ornatum*, Gdf., belongs, and which seems to be chiefly developed in American devonian strata.

1. GYROCERAS MEDLICOTTIANUM, Waagen, n. sp. Pl. VI, fig. 6.

The only fragment of this species indicates a middle-sized specimen with rather open spiral.

The diameter of the whole specimen seems to have been about 68mm, the opening in the middle of the spiral about 33mm, but it is not possible to ascertain how far the single volutions of the shell may have been distant from each other.

Only a part of the last volution has been preserved. The transverse section of this part of the shell is roundish pentagonal, about as thick as high, somewhat angular on its outer margins. The external part of the shell is slightly depressed. On the whole, the section of the fragment resembles very much the drawing by Sandberger (Rheinisches Schichtensystem) on Pl. XIII, fig. 3. The ornamentation consists of a row of high prominent tubercles along the outer margin of the shell which are not quite the breadth of the whorl distant from each other. Near the inner margin of the whorl there is a second row of tubercles, which are, however, much smaller and twice as numerous as those on the outer margin. On the external part of the shell two obtuse longitudinal ridges are present, which border a median excavation on both sides.

On the greater part of the fragment there are remnants of the shell. The shell is very thin, and covered by strong lamellar lines of growth. These lines form a very deep sinus on the external part of the shell, show a slight convexity on the lateral region, have a second sinuosity on the internal margin of the whorl at the internal row of tubercles, and form again a very strong convexity on the internal or dorsal side of the shell. From these characters of the lines of growth of the shell it is apparent that the aperture has not been quite simple, but that there have existed a large dorsal and two lateral prominences or shelly lobes, and a deep ventral indentation.

The septa are tolerably numerous, about the fourth part of the height of the whorl distant from each other. The sutural line of the septa can only be observed at the lateral parts of the shell, where it is slightly excavated. The siphon is very indistinct indeed, but it seems to be not quite central, but shifted slightly towards the internal or dorsal side of the whorl.

The dimensions, which have already been partly indicated above, seem to be as follows:—

	mm.
Diameter of the whole shell (about)	68
Inner diameter of the spiral (umbilicus) about	33
Height of the aperture	20
Thickness of the aperture	19
Height of the whorl 40mm. distant from the aperture	16
Thickness „ „ „ „	16

Locality and geological position.—The only fragment of this species in the Salt-range collection was found by myself in the uppermost beds of the middle

division of the Productus-limestone at Khúra, in a marly layer between the limestones, together with a great many other fossils, which I shall have to describe later on.

Remarks.—There is no species of carboniferous age known to me which could be compared to this shell. The forms described by de Koninck are all very distinct, and of the four species of *Gyroceras* quoted by Bigsby from "Famignoul" I could not get any definite information. It is very unfortunate that in Bigsby's "Thesaurus Carboniferous" every kind of reference is absolutely wanting, and that, on the other hand, lists of fossils, like that of Dupont in his Geology of the country around Dinant, which are entirely useless for palæontological purposes, should be allowed to encumber the tables of Bigsby's work with a ballast of meaningless names.

Of older species, chiefly devonian forms, several bear a certain resemblance to *Gyr. medlicottianum*, but all of them have got only a single row of tubercles on each side of the whorls, like *Gyr. ornatum*, Gdf., and its relatives. One single American species, though also provided with but one row of tubercles, shows only two longitudinal ridges on the external part of its shell in combination with the other ornamentation, and thus seems to be more closely related to the Indian shell than any other species; this is *Gyr. spinosum*, Conr., out of the devonian rocks of New York.

Genus: ORTHOCERAS, Breyn.

This genus has been so admirably described and discussed in every direction by Mons. Barrande that there will elapse a good many years before it will be possible to add any new observation to those recorded in Barrande's classical work. It would be simply ridiculous for me to attempt to go into any details about this genus with the aid of the scanty materials at hand, and I should only be able to copy what has previously been written by Mons. Barrande.

This excellent observer has divided the species belonging to the genus into seventeen groups, according to the different modes of ornamentation exhibited on their shell. Of all these, only two are represented in the Salt-range: the group No. 9 characterised by "Anneaux et stries transverses," and group No. 17 with "Teste lisse ou avec stries inconstantes." This latter group is, however, somewhat doubtful, as the shell of the specimens I have got for description is not sufficiently well preserved to state positively if it has been entirely smooth, but as far as observation is possible, this seems to have been the case. Otherwise, the Salt-range species might have belonged to Barrande's group No. 13. In order to make these groups appear uniform to the usage I have adopted in this work, I am compelled to use names for them which have already long since been introduced by former writers, but which I am inclined to understand in a more limited sense than has hitherto been generally accepted; thus I mean to include in the "Annulata"

only the group No. 9 of Barrande, whilst in the "Lævia" only group No. 17 will be included.

Up to the present three species of *Orthoceras* have been described from the Salt-range, *Orth. decrescens*, Kon., *Orth. rachideum*, Kon., and *Orth. vesiculosum*, Kon. I must, however, state here that I can only consider the first of the three to be really a species of *Orthoceras*, the other two very likely must be classed with quite different forms of organic life. Among all the ample materials I have got from the Salt-range, there are several fragments of an *Orthoceras*, which are very likely to be considered as identical with *Orth. decrescens;* but though there are several bodies which very well agree with the description of the other two species of *Orthoceras*, I was led, after a very careful examination of these bodies, to consider them either as *Sponges* or as *Foraminifera;* and not a trace of a true *Orthoceras* in any way similar to de Koninck's description could be detected. Among the materials the Geological Society of London kindly lent me for description, there is a specimen which has been labelled by Mons. de Koninck himself as *Orth. rachideum*. This specimen, though not being the one from which the species was described originally, is yet of very high value, as the other specimens, which are stated to have been sent to Calcutta, seem to have been lost. Now, this specimen in every way agrees with the bodies mentioned above, and there is no doubt that it also, though very badly preserved, must be considered as representing the remains of some *Protozoan*. In describing those bodies as species of *Orthoceras*, not the slighest blame can be put on the learned author, who had only materials of very inferior preservation at his disposal, as even the excellently preserved specimens I have for description have been declared at first sight, by most of the palæontologists to whom I have shown them, to be fragments of an *Orthoceras* shell. Only after a closer examination the real nature of these bodies could be detected. I shall have to describe them more accurately later on in this work.

Thus there remains only one species of *Orthoceras* which has been previously described from the Salt-range. To this I am able to add three more, so that altogether I shall have to describe here four species of the genus. Two of these belong to the "Annulata," the two remaining to the "Lævia." The Annulata which I shall describe under the names of *Orth. cyclophorum*, W., and *Orth. oblique-annulatum*, W., are restricted to the upper division of the Productus-limestone; the Lævia, on the contrary, begin with *Orth. decrescens*, Kon., in the middle division of the same formation, and are represented by another species in the upper division.

As the name *Orthoceras decrescens* has, however, already been used by Billings in 1853 for a silurian species, I am compelled to introduce a new name for the Indian form, and shall thus call it *Orth. punjabiense*.

The geological distribution of the genus *Orthoceras* is very instructive, and requires some remarks. During silurian and devonian times the genus was in species as well as in individuals numerically by far the most conspicuous of all the

Cephalopoda; only the *Goniatites* during the devonian period have furnished a greater number. In the carboniferous period the three genera *Nautilus*, *Orthoceras*, and *Goniatites* are about equally rich in species; whilst in permian times *Nautilus* and *Goniatites* seem to preponderate over the species of *Orthoceras* known to exist at that period. In the Salt-range the genus *Orthoceras* is equally scarce in species as in individuals, and four species of that genus have to be brought into comparison with ten species of *Nautilus* and seven species of *Ammonitidæ* distributed into four genera. This grouping of the *Cephalopoda* in the Productus-limestone strata of the Salt-range recalls much more that existing in triassic than that occurring in palæozoic formations.

I. Division: *ANNULATA.*

1. Orthoceras cyclophorum, Waagen, n. sp. Pl. VI, figs. 7, 8.

It is with great doubt that I introduce this new species, as the materials upon which I am compelled to found it are very insufficient, but I cannot identify the fragments at my disposal with any of the species hitherto described, and thus I can only fix the form by a new name.

The general form of the shell must have been very long conical, the sides being very gradually tapering, but not quite equally so during the entire length of the shell. One of the fragments is narrower at its top than it is at its bottom, and from this it would appear that the shell was somewhat inflated in the middle. The surface of the shell is ornamented with numerous very strong prominent rings, of which four are situated in a space equal to the transverse diameter of the shell. The rings are perfectly horizontal, but not all in one plane, being slightly elevated on that part of the shell which I take to be the dorsal one, and somewhat concave or depressed on the opposite or ventral side. On the lateral parts the sudden depression towards the ventral portion is very conspicuous. The rings are not angular, but rounded at their top.

The transverse section of the shell is perfectly circular. The septa are not very concave, and are situated somewhat obliquely in the tube. They ascend slightly on the ventral, and descend on the dorsal part of the shell. I cannot state if they were numerous or not, as all the specimens I have for description are covered with their shell.

The position of the siphon is excentric, it being removed from the centre by a little more than its own thickness towards the dorsal part of the shell. The thickness of the siphon is not very large, and it occupies not more than 0·1 of the diameter of the septum.

The surface of the shell, as far as it is possible to observe the matter, seems to be smooth as well on the rings as in the spaces between them, only transverse striæ of growth seem to be present.

The dimensions of three different specimens, the two first from Khund Ghât, the last from Khúra, are as follows :—

	I.	II.	III.
	mm.	mm.	mm.
Entire length of specimen	30	16	16
Transverse diameter at anterior end between the rings . . .	17	18	9
„ „ „ „ „ on the rings	20	20	10
„ „ at posterior end between the rings . . .	18	16	7·5
„ „ „ „ „ on the rings	21	18	8
Distance of siphon from the dorsal border	?	5	?
„ „ „ „ „ ventral border	?	10	?
„ „ the rings from each other	6·5	5	3

Locality and geological position.—There are altogether four specimens of this species preserved in the Salt-range collection. Two of them, well preserved fragments, were collected by Mr. Wynne at Khund Ghât, together with the *Nautili* I have described from the same locality, and many other fossils, and which come, therefore, from the upper division of the Productus-limestone. Out of the same division of the formation just mentioned I obtained two other fragments, one of which I found at Khúra, the other in a section near Kufri in the same bed (No. 14), in which also the specimen of *Arcestes antiquus* occurred, which I have described above.

Remarks.—This species is allied to a number of similar forms, and I have to point out here which are the differences that led me to distinguish this shell as a new species. Before all, *Orth. annulatum*, Sow., bears a great resemblance to our species, but the former differs by its more or less compressed transverse section. *Orthoceras undatum*, Flem., which is also nearly allied, has a central siphon; the same is the case with *Orth. dactyliophorum*, Kon. *Orth. annulato-costatum*, M. and W., has a more or less oval section, and the species of *Orthoceras* described by Abich from Djulfa or the Araxes have all either a different sculpture, or their transverse section is compressed and thus more or less oval.

There is a strong probability that *Orth. cyclophorum* may be in developmental connection with one or the other of the forms to which it is allied, but the studies as to this connection among the species of *Orthoceras* have been up to the present so very little developed that I cannot venture, relying only on the very scanty materials at present at my disposal, to pronounce any opinion in this direction; I must leave the solution of this question entirely to future enquiries.

2. ORTHOCERAS OBLIQUE-ANNULATUM, Waagen, n. sp. Pl. VI, figs. 9, 10.

This species is represented by a few fragments, which seem barely sufficient for the foundation of a new species, but as there are characters which do not allow of an identification of these fragments with any of the species hitherto described, and as it is, on the other hand, very inconvenient to drag along under the designation of "*sp. indet.*" a form which bears characters sufficiently distinctive to recognise

the form if found elsewhere, I prefer to give a new name to these fragments, even if they may constitute only a very bad species.

The general form of the shell is more tapering in this than in the preceding species, and thus the entire length of the shell should be less considerable. The surface is covered by not very prominent rings which are tolerably sharp in the very young shell, but rounded at their top in more adult specimens. The position of these rings is not quite horizontal, but considerably elevated on one side and depressed on the other, the former corresponds very likely to the dorsal, the other to the ventral side of the animal. Thus the rings cross obliquely over the lateral parts of the shell. They are about equally numerous as in the preceding species, about four of them being equal to the transverse diameter of the shell.

The transverse section of the shell is not circular in adult specimens, but more or less compressed and oval, but in very young specimens this compression is barely perceptible.

The position of the siphon is entirely central. The septa are not very concave and about the fourth part of the antero-posterior diameter distant from each other.

The dimensions of three fragments are as follow :—

	I.	II.	III.
	mm.	mm.	mm.
Entire length of fragment	21	16	12
Transverse diameter at anterior end from back to front . .	12	9	5·2
„ „ „ „ „ from side to side . .	10	7·5	5
„ „ at posterior end from back to front . .	10	7	4
„ „ „ „ „ from side to side . .	8	6·5	4
Distance of the rings from each other	4	2	1·5

Locality and geological position.—The three fragments of this species were collected by Mr. Wynne at Khund Ghát, together with *Orth. cyclophorum* and the species of *Nautilus* described above. All these species come from the upper division of the Productus-limestone.

Remarks.—The species which is most nearly allied to *Orth. oblique-annulatum* is undoubtedly *Orth. undatum*, Flem. The differences consist in a less strongly compressed transverse section, in more convex and more distant septa, and in rings which are more closely arranged in the latter species. The same differences exist also between our species and *Orth. dactyliophorum*, Kon., but in the latter species, the rings, of which the ornamentation of the shell consists, are arranged horizontally, whilst they are oblique in the Indian species.

From *Orth. cyclophorum*, W., described above, the species under consideration can be distinguished by the oblique arrangement of its rings, the compressed transverse section, the central position of the siphon, and the more rapid tapering of the tube. *Orth. annulatum*, Sow., which is also allied, is distinct by its eccentric siphon.

II. Division: *LÆVIA.*

1. Orthoceras punjabiense, Waagen, n. sp. Pl VI, fig. 11.

1863. *Orthoceras decrescens*, Koninck: Fossiles Paléozoiques de l'Inde, p. 5, Pl. VIII, fig. 4.
(non *Orthoceras decrescens*, Billings, 1853, Rep. of Progr.)

The materials of this species at my disposal are very scanty indeed, and the specimen figured by M. de Koninck is by far the best which has been found up to the present.

The general form of the shell is very long, conical, tapering very gradually. The surface is perfectly smooth; even the outer surface of the shell, which is tolerably well preserved in one of the fragments collected by me, seems to be smooth, without transverse or vertical striation.

The transverse section of the tube is perfectly circular, the siphon narrow and central. The septa are not very strongly concave and are very distant from each other, rather more than their own diameter. The specimen figured by Mons. de Koninck is evidently a full-grown shell, and this is the cause of the gradual decrease in the length of the air chambers. The sutural lines of the septa are not undulating, but entirely straight.

Of so called "stries creuses" on the cast of the body chamber nothing has been observed by Mons. de Koninck.

There is no use in fixing any measurements, as the form of this species is so simple that every thing can be observed on the drawing; and, on the other hand, the specimens at my disposal are such very small fragments, that the mode of tapering can barely be observed on them.

Locality and geological position.—The specimen which has been figured by Mons. de Koninck was collected at Músakheyl, and there is every probability of its coming from the top beds of the middle division of the Productus-limestone. Three very small fragments, which were collected by myself, I found at the limit between the middle and the upper division of the Productus-limestone, west of Khúra.

Remarks.—It is a fact worthy of notice that this species is much more closely allied to some of the triassic forms than to the upper palæozoic species of *Orthoceras*. What characterises the Indian form most is the great distance between the septa, which only in full grown specimens is reduced in the last air chambers. There is no palæozoic form with a central siphon that I know of which has equally distant septa except *Orth. regulare*, Schloth., and its allies, which, however, bear so singular an internal structure as is not exhibited by more recent forms. Of carboniferous species *Orth. calamus*, Kon., which is apparently most nearly allied, has got more numerous septa. The same is the case with *Orth. geinitzi*, Orb., in which species the septa are only about half their own diameter distant from each other. As soon as we turn, however, to triassic forms, we find several species, which bear a great

resemblance to the shell under consideration. *Orth. triadicum* Mojs., *Orth. lateseptatum*, Hau., and *Orth. dubium*, Hau., are all species with a central siphon and very distant septa, but chiefly *Orth. lateseptatum* very closely resembles our species, the only marked difference seeming to consist in its shell, which is transversely striated, and in the more considerable size the species seems to attain.

2. Orthoceras, *sp. indet.* Pl. VI, fig. 12.

This species is represented by a single rather badly preserved specimen which seems not sufficient to found a new species. The form is certainly very nearly allied to that of the preceding species. The cone is equally slowly tapering, the septa are not very strongly concave, and equally far distant from each other as in *Orth. punjabiense*, the siphon seems to be central, but the transverse section of the tube is somewhat triangular, whilst it is circular in the preceding species. For this reason I am not able to unite this specimen with *Orth. punjabiense*, but must consider it as indicating the existence of one further species of the genus, which though very nearly allied to the form mentioned, yet is distinct by its somewhat triangular section.

Locality and geological position.—The specimen by which this species is indicated was collected by Mr. Wynne at Khund Ghât with many other fossils which all are characteristic of the upper division of the Productus-limestone. The species thus seems to be somewhat more recent than *Orth. punjabiense*, W.

PISCES—CEPHALOPODA.

SUPPLEMENT.

Specimens from the Trans-Indus continuation of the Salt-range.

Collected (in 1878-79) by A. B. Wynne, *Geological Survey of India.*

Family: *COCHLIODONTIDÆ*, *v.* p. 11.

Genus: PSEPHODUS, Agass.

It is extremely difficult to find out what ought to be comprised under the above name, as neither description nor figure was ever published by Agassiz, and, properly speaking, the genus ought hardly to be retained; but since the typical species was figured afterwards by Portlock and, as it seems, from specimens which had been seen by Agassiz himself, the name might be utilized to replace the more recent name of *Aspidodus* introduced by Newberry and Worthen.

From the species which have hitherto been assigned to the genus, it appears that it comprises teeth of very variable outline, but all more or less twisted and with a smooth surface, on which only a low, rounded elevation can be observed placed longitudinally on the tooth, sometimes not extending over the whole length of it, but stopping at about the middle. The teeth are distinct from *Cochliodus* by their more flattened and less enrolled general form, and by the greater smoothness of their surface.

Up to the present but very few species of the genus have been described, and besides the typical one, *Ps. magnus*, Ag., there are only some five or six species known. In India the genus is represented by two species, which occur in the upper and middle divisions of the Productus-limestone.

1. Psephodus indicus, Waagen, n. sp. Pl. VII, figs. 3 & 5.

The general form of the teeth belonging to this species seems to be very variable, and it is extremely difficult to reduce the characters of the species to writing.

There are two teeth, which seem to belong to one and the same species, the

larger and more trapezoidal one being apparently a mesial tooth, whilst the smaller and narrower one, which is at the same time more enrolled, seems to be a terminal one. Both have been adapted to the similarly curved jaw.

The larger tooth is more or less trapezoidal, indistinctly five-sided, with one corner decidedly more prominent than the others. The surface of the tooth is smoothed and regularly arched in every direction, but from the prominent corner of the trapezoid there extends a low rounded ridge to about the middle of the arched surface, bounded on both sides by a flat leaf-shaped impression. The substance of the tooth is rather thin, no part corresponding to the root, as it exists in the teeth of sharks, having apparently ever been present. The upper surface of the tooth is covered by a fine granulation, quite observable with the naked eye. Under the lens the granulation appears to consist of little warts, each of which is pierced by a dentine tube.

The margins of the tooth are smoothed, not crenulated.

The smaller tooth is more or less irregularly rectangular, much longer than broad and strongly twisted. The surface is much more arched longitudinally than in the direction of the breadth. In a similar manner, as in the larger tooth, there is a low ridge originating about in the middle, and stretching from there to one of the corners of the rectangle. It is also bounded on both sides by leaf-shaped flat impressions.

The body of the tooth is very unequal in thickness, the flat end being rather thick, whilst the other strongly enrolled extremity is very thin. There seem parts of the compact jaw to be still preserved on the lower surface of the tooth. The surface sculpture is identical with that of the larger tooth.

The dimensions of the two teeth are as follows:—

	I.	II.
Greatest length of tooth	33 mm.	30 mm.
„ breadth of tooth	25 „	17 „
Height of tooth	11 „	12 „
Thickness of tooth at one end	7 „	9 „
„ „ at the other end	3 „	2 „

Locality and geological position.—There are two specimens and a small fragment of this species in the Trans-Indus collection. The larger of these was found by Mr. Wynne at Kiri, in the upper division of the Productus-limestone, the smaller tooth, together with a fragment of another specimen, at Bilot, apparently in the same beds as at Kiri. Thus the species seems up to the present to be restricted to the upper division of the Productus-limestone.

Remarks.—This species is easily distinguishable from all other species of *Psephodus* hitherto described by the low rounded ridge which extends from the middle of the tooth to one of its corners, and by the leaf-shaped flat depressions which are situated on both sides of this ridge. The species that can at all be compared with the present one is *Pseph. minor*, Trautsch., from the upper mountain-limestone of Miatchkowa. Trautschold's species is, however, much smaller

than the Indian one; and among all the teeth of the species figured by Trautschold, there is a single small one showing traces of a similar ridge to that occurring in *Pseph. indicus*, W. More similar in its general form to our species is the genus *Arpagodus*, Trautsch., but as that genus is said by its author to possess fine transverse ridges like *Orodus*, the Indian teeth cannot be compared with it.

2. PSEPHODUS DEPRESSUS, Waagen, n. sp. Pl. VII, fig. 4.

Though the tooth on which this species has been founded is not entire, yet it can safely serve for the definition of a separate species, as it most certainly indicates the existence of a second species of *Psephodus* in the sea which once covered the Northern Punjab.

The tooth seems to have possessed an irregular trapezoidal outline, longer than broad, and, when entire, much larger than any tooth of the preceding species. The specimen is very little twisted, nearly entirely even, rather strongly arched in a transverse direction, but very little so longitudinally. There seems to run along nearly the whole length of the tooth a rounded very broad low ridge, not accompanied by well-defined depressions on both sides. The surface is very finely punctured, the puncturing being only visible with great difficulty without the lens.

As in the preceding species the tooth is very unequal in thickness at different ends. There is somewhat of a slightly developed root present, showing in the section some calcigerous cells. The crown part of the tooth is composed of very fine and closely packed dentine tubes.

The dimensions of the tooth, as far as they can be taken, are as follows: —

Greatest length of tooth	?
„ breadth „	26 mm.
Height of tooth	11 „
Thickness of tooth at one end	9 „
„ „ at fracture	7 „

Locality and geological position.—The only specimen was collected by Mr. Wynne at Bilot in a crinoidal limestone belonging to the upper, or, more likely, to the middle division of the Productus-limestone.

Remarks.—This species is not difficult to distinguish from *Pseph. indicus*, W., by the ridge which extends nearly over the whole length of the tooth, and by the absence of impressions on both sides of it. Besides this the puncturing of the surface is much finer and more closely arranged in *Pseph. depressus* than in *Pseph. indicus*.

In the general form of certain teeth also *Pseph.* (*Aspidodus*) *crenulatus*, N. and W., bears a great resemblance to our species, but it can easily be distinguished by the crenulation the American species bears along the margins of its teeth, which is absent in *Pseph. depressus*, W.

ICHTHYODORULITES.

Genus: XYSTRACANTHUS, Leidy, *v.* p. 18.

3. XYSTRACANTHUS GIGANTEUS, Waagen, n. sp. Pl. VII, fig. 2.

This is the largest species of *Xystracanthus* that has hitherto been described, as the spine, if complete, must have been at least 0·3 m. in length. The specimen is, however, only a tolerably large fragment, but it is not only interesting on account of its representing a new species, but also because it throws new light on the systematic position of the genus *Xystracanthus*.

According to this fragment, the general form of the spine was broadly conical, tapering somewhat rapidly towards the apex, strongly compressed on both sides, obtusely acute in front, and apparently rounded behind. The whole spine is well curved towards the front, which causes the anterior outline to be strongly concave, whilst the posterior one is correspondingly convex.

The lateral compression increases considerably on the anterior margin towards the base of the spine, so that this margin, which is obtusely angular above, is very acutely sharpened near the base, forming at the same time a hatchet-shaped process.

More than half of the entire length of the spine has been inserted in the flesh, or has been covered at least by the skin. The spine begins to be coated by an enamel layer only about halfway up its length, and the lower limit of this coating crosses very obliquely the lateral parts of the spine, beginning on the anterior margin nearly 60 mm. lower down than on the posterior one.

With the enamel coating the surface sculpture also begins to appear. This consists of two rows of large longitudinally elongated squarish tubercles on the anterior margin, and of very numerous small granular tubercles on the lateral parts, arranged in closely packed longitudinal rows, which seem to be parallel with the posterior margin of the spine, but not so with the anterior one. These small tubercles are so closely arranged that they nearly touch each other on all sides, and when well preserved they show a very fine stellate sculpture with a central apex. The large tubercles on the anterior margin are entirely smooth.

Below the enamel there is a thick layer of very compact bony substance which forms the outside layer of the whole inserted part of the spine. The surface of this bony substance appears under the lens finely granulated like "chagrin" leather.

The centre of the compact part of the spine is occupied by spongy cellulose bone substance pierced for the entire length of the spine near the anterior margin by a canal, which probably served for the reception of a large blood-vessel. The pulp cavity seems to have been very small, though extending up to the apex of the spine, and very far removed from the anterior margin.

The dimensions of the fragment here described are as follows :—

	mm.
Whole length of fragment	158
Diameter from the anterior margin of the spine to the anterior margin of the pulp cavity at the upper fracture	42
Diameter from the anterior margin of spine to anterior margin of pulp cavity at second fracture	55
Transverse diameter at upper fracture	19
„ „ at second fracture	20
Distance of the lower termination of enamel on the anterior margin from the hatchet-shaped process	73
Distance of the lower termination of enamel on the posterior margin from the hatchet-shaped process	154

Locality and geological position.—This large fin ray was collected by Mr. Wynne at Bilot in the uppermost beds of the Productus-limestone.

Remarks.—It seems to require some words to justify the position of the species here described in the genus *Xystracanthus*. Leidy, in proposing the new genus, only had at his disposal an upper end of a spine, in which the basal or inserted part had been broken off; in the original specimen, therefore, only the characters of the ornamentation and the forward direction of the curve of the spine could be observed. St. John and Worthen, after having compared Leidy's original specimen, united with the genus several other forms, of which some had the basal part preserved. From these specimens these authors described the genus as allied to *Physonemus*, Agass., from which it is said to be distinct by its more slender form and the "less preponderance of the antero-inferior shoulder;" the specimens figured by them show, however, this process not only little developed, but nearly quite obsolete. In this respect our spine differs widely from the American specimens: the antero-inferior process is here laterally very strongly compressed, strongly prominent, and with a cutting edge, but yet in general outline it is not so very different from *Physonemus*, chiefly from the typical species figured by McCoy.

If we compare, however, the surface sculpture of our spine with that of the typical species of *Xystracanthus*, it appears that this is nearly identical, so that had we only the ornamented part of the fin ray for comparison, the identification with the genus would be beyond doubt, and the peculiarities of the basal part of the spine do not seem such as to necessitate the creation of a new genus; on the contrary, they only tend to show that the antero-inferior process in *Xystracanthus* can be very differently developed in different species of the genus.

As to species, the distinction of the present fin ray from those of other species is not very difficult. Most nearly allied to *Xystr. giganteus*, W., seems to be *Xystr. major*, W., described ante p. 19; this species can, however, be distinguished from the present one by its being more sparingly tuberculated on the lateral parts, and by these lateral tubercles being smooth and not provided with a stellate sculpture; besides which there are four rows of larger tubercles near the anterior margin instead of two as in the present species.

Xystracanthus mirabilis, St. J. and W., is also in its surface sculpture very nearly related to our species. The general arrangement of the tubercles is more like in *Xystr. major*, but the small lateral tubercles, chiefly those figured: Illinois' report, Vol. VI., Plate 20, fig. 1 *l*, are exactly alike in *Xystr. mirabilis* and *Xystr. giganteus*, W.; the large tubercles on the anterior margin, on the contrary, are smooth in the Indian species, and carinated and provided with an acute extentric apex in the American fin ray.

The other species of *Xystracanthus* described up to the present can barely be compared to the Indian fossil, most of them being much smaller and differently sculptured.

Genus: THAUMATACANTHUS, Waagen, n. gen.

This genus is founded on a single fin-ray of very peculiar construction.

This ray is of medium size, laterally compressed, very gradually tapering and slightly arched towards the front, so as to present a concave outline on the anterior margin and a convex outline on the posterior one. The spine has been deeply inserted in the flesh, and the part of it which has been free, not inserted, is covered by a thin layer of enamel, and shows an ornamentation similar to that of *Gyracanthus*, Agass. The enamel-covering terminates below in a very oblique line, reaching much further down on the anterior margin than on the posterior one.

The most strange part of the spine is that inserted in the flesh. It consists of rather solid bony substance, and is at its lower termination transformed into a thick rounded process, which bears a well-developed articulation, apparently corresponding to a similar articulation on a bony support, on which the spine rested. The inserted part of the ray is flattened and enlarged behind, and split open for a considerable distance to allow of the entrance of nerves and blood-vessels to the large pulp cavity, which occupies the greater part of the upper half of the ray in such a manner as to be surrounded only by comparatively thin bony walls.

The articulation on the lower end of the ray is rather complicated; and it appears not impossible that the animal was able to stiffen the spine, when erected, on its support by slightly twisting it, as several holosteous fishes now living are wont to do.

The systematic position of the animal to which this spine belonged is very doubtful indeed. The upper half of the spine, if found separated, would, beyond any doubt, be attributed to some *Cestraciont*, but there is, so far as I am aware of, no *Selachian* of any kind known that bears its fin-spines on bony supports. It will therefore barely be possible, according to the fragmentary evidence before us, to assign this animal with any certainty to a place in the system; it cannot, however, be denied that the enamel covering, and the kind of sculpture of the upper part of the ray, and the deep and oblique insertion of it, are in favour of the opinion

that it may have been some strangely developed *Selachian* to which the ray had once belonged.

The only thing which possibly could be compared to the present fossil has been figured recently by Mivart in the Transact. Zool., Lond., vol. X, Pl. XLIX, fig. 1. This is the first dorsal fin of *Callorhynchus antarcticus*. Though also in this species the spine itself is without an articulation, yet it seems to be immediately joined to a triangular plate, which is apparently articulating with a cartilaginous process of the dorsal vertebra. If this plate were ossified and firmly grown together with the spine, something very similar to *Thaumatacanthus* would result. But these are all vague analogies, and I do not think it would be advisable for such reasons to refer the new genus to the *Chimæridæ*.

1. THAUMATACANTHUS BLANFORDI, Waagen, n. sp. Pl. VIII, fig. 1.

There is only a little more than half of the entire length of this spine preserved, but this is sufficient to characterise the species.

The general outline of the species is very elongated conical, very gradually tapering, compressed from both sides, and slightly incurved towards the front.

The uppermost inserted part of the ray is covered by a thin layer of enamel, which bears a very characteristic ornamentation. On the anterior margin of the ray there is a row of very large, rounded, smooth knobs of tubercles, which are not constricted at their base, but rise gradually up from the surrounding flat part. They are very distant from each other, at least twice their own diameter. On both sides of this marginal row there follows a very irregular row of medium-sized tubercles, which do not form a straight line, but deviate wherever they meet with one of the large marginal knobs. Only after this second row of tubercles the regular ornamentation of the lateral parts of the ray commences. This consists of oblique and very irregular rows of very small tubercles, closely arranged within the row, but the several rows of which are more distant from each other.

Each individual row becomes almost extinct in the middle of the sides of the ray, but reappears again, retaining the same direction near the posterior margin of the ray. The specimen is not well enough preserved, to ascertain in what manner the rows of the two sides of the spine meet on the posterior margin.

The line of insertion of the spine is rather oblique, and follows approximately the direction of the rows of small tubercles developed on the lateral parts of the spine.

The inserted part of the spine is very remarkable in its form. Like in other *Ichthyodorulites*, the anterior part of the inserted extremity is much longer than the posterior one, and thus the spine at its lower termination is cut off obliquely. But in this case the anterior part, instead of being simply conical, is rounded off below and transformed into an articulation as we are wont to see on the phalanges of

the hand or foot, or other limb-bones. The articulation itself consists of a rounded protuberance in the middle, bounded on both sides by flat impressions, which mark off two rounded shoulders, in which the lower extremity of the articulating part terminates on both sides. On the anterior margin there extends from the protuberance in the middle a thick and high somewhat curved ridge, covered on both sides by rugosities for the insertion of muscles, and which extends up to the end of the inserted part of the spine. Near the base of this ridge there is on each side a deep somewhat squarish elongated groove for the reception of bony parts of the support in the erected state of the spine. These grooves are cut off above by an angular, somewhat obliquely placed, strongly rugose ridge. Above this latter ridge there is again an impression covered by rugosities for the insertion of muscles.

On the posterior margin a sharp narrow ridge extends a short way up, from the terminal middle protuberance of the articulation, and is then suddenly divided into two high, projecting lamellar bony parts somewhat triangular in form, extending a long way up the spine, till the upper termination of the inserted part of the spine is reached. Between these two lamellæ there remains an open space, forming a long narrow slit for the entrance of nerves and blood-vessels to the pulp cavity. Immediately above the terminal protuberance of the articulation, there is on each side of the sharp posterior ridge a deep oval groove for the reception of bony parts of the support in the recumbent position of the spine; these grooves suddenly deepen immediately above the terminal protuberance and then gradually get shallower. Above them there is a somewhat trapezoidal rugose space for the insertion of muscles.

From the lateral shoulders, which have been described as being situated on both sides of the terminal protuberance, a thick, rounded, very prominent ridge extends on each side a long way up, without, however, reaching the upper end of the inserted part of the spine. Not far from its upper termination, the ridge is most prominent, swollen, and forming a thick mastoid process. From there it falls quickly off, with a slight curve towards the front. In front of the mastoid process there is an elongated flattened space bounded on both sides by very low barely perceptible rounded ridges, the flattened space as well as the ridges being approximately parallel to the insertion line of the spine, indeed the upper ridge seems to coincide partly with that line.

The whole mastoid process seems to have served for the insertion of muscles.

The pulp-cavity is very large; the bony substance by which it is enclosed being thickest on the anterior margin and rather thin everywhere else.

The dimensions of the specimen are as follows:—

	mm.
Total length of spine about	? 170
Length of preserved part	105
„ inserted base of the spine at the anterior margin	47
„ „ „ „ posterior „	75

Distance of the top of the terminal protuberance to the top of the mastoid process . .	32
„ „ „ „ „ upper corner of the anterior grooves.	29
„ „ „ „ „ upper termination of the posterior grooves	22
„ „ „ „ „ base of the posterior grooves . .	11
„ „ „ „ „ „ „ slit . .	15
Total length of the posterior slit	57
Transverse diameter of spine at the upper end	12
„ „ „ at base of mastoid process	16
„ „ „ on top of „	34
„ „ at the base of the spine	21
Antero-posterior diameter at the upper end of the spine	20
„ „ at greatest breadth of spine	38
„ „ at the base of the spine	19

Locality and geological position.—The specimen described above was collected by Mr. Wynne in a very hard calcareous yellowish-grey sandstone at Kiri. This sandstone seems to be among the highest beds of the Productus-limestone, as some doubt is expressed on the label attached to the specimen as to its possibly being triassic. In the same block of sandstone, however, in which the specimen had been enclosed, I detected a fragment of *Dentalium herculeum*, Kon., and thus there can be no doubt that the rock containing the two species belonged still to the Productus-limestone formation.

Remarks.—The fossil here described is so peculiar that it cannot be compared with any species that has been hitherto detected.

As to the nature of the fossil there can be no doubt, the sculpture exhibited by the enamelled part is too characteristic to be mistaken.

The whole space of the spine is perfectly symmetrical. Though one side of it is much mutilated by weathering, this can easily be seen. The spine, therefore, must have had its position somewhere in the middle line of the body of the animal to which it belonged, and thus was very likely a dorsal ray.

The mode of preservation of the fossil is not without interest. On the weathered surface the substance of the bone is in many places tinted blue and green, thus resembling very much the bones found sometimes in the cupriferous sandstone of the Ural.

Family: *AMMONITIDÆ*, *v.* p. 21.

Genus: SAGECERAS, Mojs., *v.* p. 37.

3. SAGECERAS WYNNEI, Waagen, n. sp. Pl. VIII, fig. 2.

Among the materials recently collected by Mr. Wynne, there is a beautiful new species of *Sageceras*, which I name in honour of its discoverer *Sag. wynnei*.

The general shape of the shell is disciform, with compressed whorls and a very small umbilicus.

The whorls are much higher than broad, with flattened, only very slightly convex, sides and a flat depressed siphonal part bordered on both sides by angular margins. The umbilicus is very small and deep, not bordered by angular margins, the lateral parts of the whorls bending down to the umbilical suture in a regular flat curve. The involution of the whorls is very great, but though this is the case yet the whorls increase so rapidly in height, that only one-third of the height of the last whorl is occupied by the involuted part of the preceding one. There remains only a very narrow margin of the inner whorls visible within the umbilicus.

No trace of the shell is preserved on the specimen received for description. The cast is entirely smooth, without any trace of sculpture.

The shape of the shell seems to have been very different at different stages of growth. The first two or three whorls have a broad, depressed, rounded section, about as broad as it is high; then the section of the whorls increases more rapidly in height and becomes an elongated oval; only on the fourth or fifth whorl is the flattened siphonal part developed, bounded on both sides by angular margins; and not till then, at a diameter of the shell of about 30 or 40 mm., are all the characters of the species fully expressed.

As in all the species of *Sageceras*, so in this one, the sutural lines are very characteristic. The siphonal apparatus consists in a long narrow lobe, terminating very distinctly in two fingers. The sides of this lobe are nearly parallel, each provided with six or seven denticulations. The lobe is bounded on both sides by saddles not broader than, and as long as, the lobe. Corresponding to the six indentations of the lateral line of the siphonal lobe, there are again six indentations on the inner wall of this narrow saddle, in such a manner that the whole saddle gets a perfectly symmetrical outline, the upper termination of it showing the figure of a shamrock leaf. This saddle is situated precisely on the exterior angular margin of the whorl, so as to be placed with one side on the flattened siphonal part, with the other on the lateral part of the whorl. Next to this saddle follows a lobe which is the largest in the whole series. It is somewhat leaf-shaped, terminating in two broad unequal fingers, of which the outer one is larger, and bearing near its base on the outer side a somewhat conspicuous tongue-shaped finger, which is joined immediately to the serrated inner margin of the narrow saddle described above. The next lobe is much shorter than the preceding one, also terminating in two unequal fingers, of which, however, the inner one is the larger. This lobe is bounded on its outer side by a rather short elongated oval perfectly entire saddle, on its inner side by a similarly shaped saddle, which reaches, however, much further up. The third lateral lobe is again a good deal larger than the second, nearly as large as the first, also terminating in two fingers, of which the interior one is larger. The next following three lobes are perfectly similar in shape to the one last described, but gradually diminishing in size; the saddles between them are all entire, tongue-shaped, and gradually diminishing in size. After the sixth lobe on the lateral part of the whorl is reached, the suture presents only the aspect of an undulating line, the terminal fingers of

the lobes having gradually disappeared. There are yet some five or six auxiliary lobes formed by the curves of this undulating line. The whole suture occupies a tolerably regularly shaped triangle, two sides of which are formed by radii of the spiral, touching on one side the culminating points of the auxiliary saddles and of the narrow saddles of the siphonal apparatus, and on the other side the terminal fingers of the more prominent lobes; only the middle lobe of the siphonal apparatus falls far short of this radius.

The measurements of the specimen here described are as follows :—

Diameter of the shell about	103 mm.
„ „ umbilicus „	6 „
Height of the aperture from the umbilical suture	58 „
„ „ „ siphonal side of the preceding whorl	41 „
Thickness of the aperture	25 „

The greatest thickness lies about in the middle of the whorls.

Locality and geological position.—The specimen described above was collected by Mr. Wynne at Bilot, in the upper division of the Productus-limestone.

Remarks.—This species belongs to that section of the genus *Sageceras* which I have distinguished on page 39 under the name of "Section of *Sag. orbignyanum*, Vern." Like all the species belonging to this section, this species also exhibits the peculiar siphonal lobe, which does not occur in any other group of the *Ammonitidæ*. This character, combined with the geological distribution of the single species, seems to indicate with very great probability the existence of two separate genera, one of which is of chiefly palæozoic, the other of chiefly mesozoic occurrence. As the name *Sageceras* has been proposed by Mojsisovics chiefly to include the triassic species, like *Sag. haidingeri*, Hau., which are all deprived of the above mentioned singular siphonal lobe, there must be created a new name for the palæozoic species, and I propose the name of MEDLICOTTIA, Waagen, for these forms, by the use of which distinctive designation it would be immediately apparent to what group one or the other single species belongs. The new genus would thus be composed of the following species :—

Medlicottia orbignyana, Vern.
„ *artiensis*, Gruenew.
„ *primas*, Waagen.
„ *sakmarœ*, Karp.
„ *wynnei*, Waagen.

It is not easy to give a general characteristic of the genus from the five species hitherto known to belong to it, but to all of them the very characteristic development of the siphonal apparatus seems to be common. This character is not only observable on the casts, when the sutural line can be really observed, but it is also expressed in the shell when the sutural line is perfectly covered up. All the forms hitherto detected have the siphonal side either excavated and bounded on both

sides by high and sharp crests, or the siphonal side is simply flattened, and defined on both sides by angular margins. In both cases the high and narrow saddles developed on each side of the siphonal lobe are situated exactly below the crests or the angulated margins; these saddles are strongly serrated from both sides, and the denticulation of the opposite sides of the saddle correspond exactly with each other; thus, little oval tubercles are formed, which appear not only on the casts, but also less strongly on the shell, and thus also those species, of which the sutural line is not exactly known, like in *Sag.* (*Medl.*) *sakmaræ* or *Sag.* (*Medl.*) *artiensis*, can easily with all desirable certitude be attributed to the genus. It is therefore certainly a mistake, if Mojsisovics treats these latter species as not belonging to his genus *Sageceras*, but as forms very nearly agreeing with the types of *Trachyceras*, Laube. Though the sculpture to a certain extent may recall that of *Trachyceras*, yet the sutural lines, which are partly known from *Medl. sakmaræ*, at least forbid the comparison of these forms to *Trachyceras*. *Medl. artiensis*, however, is so very nearly related to *Medl. sakmaræ*, that both might even specifically be identical. (Compare Karpinsky: Geological investigations in the Gouv. Orenburg, Verh. k. Mineral. Ges. Petersb., 1874, page 286.) The Salt-range species of *Sageceras*, as well as everything else that occurs there, are treated by Mojsisovics indiscriminately as "permian," in a rather arbitrary manner. I do not think that any proofs are in his hands to justify this assertion. (Verh. k. k. Geol. Reichsanst. 1879, pp. 137, 138.)

The systematic position of the genera *Sageceras* and *Medlicottia* is not quite easy to point out, and chiefly the latter genus presents an assemblage of characters which bear most conflicting evidence. If the family of *Goniatitidæ*, as proposed by Barrande, had to be maintained, the genus *Medlicottia* would, beyond any doubt, have to be united with this family, as appears most undoubtedly from a comparison of the sutural lines as exhibited by the three species *Medlicottia orbignyana*, *primas*, and *wynnei*. The numerical law as to the distribution of the lobes, which has been ascertained to prevail in the *Ammonites* by L. v. Buch, is not in the slightest degree developed in the sutural lines of the species mentioned, and in this respect they resemble entirely the sutural lines occurring in by far the greater number of *Goniatites*. To these in a general way entirely goniatitic sutural lines there stands in most striking contrast the development of a siphonal tubercle, though small, in *Medl. wynnei*, which is suggestive of a direction of the siphonal funnel towards the front. Very remarkable also is the sculpture, as well as the direction, of the striæ of growth in *Sageceras* and in *Medlicottia*. Instead of possessing an emargination on the peripheral part of the aperture, as in the case in the *Goniatites*, the sculpture, as well as the striæ of growth in both genera, are directed distinctly towards the front on the siphonal part of the shell, as in the true *Ammonites*.

As to species the one here described is most nearly allied to *Medlicottia* (*Sageceras*) *artiensis*, Grunewald; and the affinity of both species seem to be so great, that I think it highly probable that both stand in a developmental connection

with each other. The chief difference between *M. artiensis* and *M. Wynnei* seems to consist in falciform ribs, which are exhibited by the former species, whilst they are absent in the Indian fossil. But from the very great similarity of both fossils it seems probable that they are also not very far apart in geological age.

Family: *NAUTILIDÆ*, *v.* p. 42.

Genus: NAUTILUS, Linn.

NAUTILUS GOLIATHUS, Waagen, *v.* p. 50.

A fragment of the body-chamber of a small specimen of this species was found by Mr. Wynne in the upper division of the Productus limestone at Bilot.

No new light is thrown on this species by this newly found specimen.

Class: GASTEROPODA.

Order: PROSOBRANCHIATA.

Sub-Order: CTENOBRANCHIATA.

Tribe: HOLOSTOMATA.

Family: *SOLARIIDÆ.*

Genus: EUOMPHALUS, Sow.

Though this genus has been generally accepted by most previous writers, yet it requires a detailed explanation why I use the name here.

The genus was defined by Sowerby in his Mineral Conchology in 1812; and *E. pentangulatus*, Sow., from the mountain-limestone must be considered as the typical species of the genus. This is a species with a very low depressed spire, a very wide umbilicus and angular whorls, which bear a very distinct keel on their upper or posterior surface, whilst the lower or umbilical or anterior surface is rounded, without keel. Two years previous to the definition of the genus *Euomphalus*, Montfort, in his Conchiliologie systématique, described the genus *Straparolus*, of which *St. dionysi*, Mtf., must be considered as the typical species. Now, there is no doubt, that *Euomphalus pentangulatus*, Sow., and *Straparolus dionysi*, Mtf., are very nearly related to each other; and if we regard only the larger generic divisions as they have been in use up to very recent times, both genera, *Euomphalus* and *Straparolus*, should be considered identical; and as the latter was defined at least two years previous to the former, *Straparolus* should be accepted as the only admissible name for the shells in question. When we, however, take up all the generic designations, introduced chiefly by H. and A. Adams and other modern writers, by whom also the old genera *Turbo*, *Littorina*, etc., have been divided into many minor groups, we will find that also within the genus *Straparolus* several groups can be distinguished which might be considered as of generic value. The misfortune is, that only the shells are accessible to our observation, and of these even, in most cases, the opercula are wanting. When, therefore, in imperfect specimens the shells show some constant differences, it may be taken for granted that if the animals were accessible to observation, even more striking peculiarities would be detected in them than are exhibited by the shells only. This consideration is strengthened by the remarks of Stoliczka regarding the genus *Straparolus*. According to his views, the animal of the species having a distinct keel on their upper surface, like *Euomphalus pentangulatus*, Sow., had a distinct insinuation of the mantle on their neck, which caused the formation of the keel.

This insinuation was more strongly expressed in the shell, when the animals were still young and able to lift up their shells frequently, but disappeared more or less on the shell when in large individuals it became too heavy, and was therefore carried more or less in a horizontal position. In shells, however, where there is no keel from the earliest stages of growth, such an insinuation of the mantle can hardly have been present at all, and thus it seems likely that the animals inhabiting keeled shells and those of shells which never bear any keel were dissimilar to a certain extent.

Now, as the name *Straparolus* was first applied to a species without keel, whilst the name *Euomphalus* was established for species with a distinct keel, the two names may be retained, the first for species with rounded whorls without any trace of a keel, the second for the species with a distinct keel on the upper surface. Thus defined, the genus *Euomphalus*, Sow., would contain chiefly palæozoic species, whilst the genus *Straparolus*, though also beginning in palæozoic strata, would go up in frequent species into mesozoic formations up to cretaceous beds.

There remain yet some genera rather nearly allied to the two above mentioned and which were even considered in several cases identical with them; these are *Schizostoma*, Bronn, *Discohelix*, Dunk., *Maclurea*, Emmons, and *Ophileta*, Hall.

Schizostoma has been united by Stoliczka with *Straparolus;* but if we consider this latter genus distinct from *Euomphalus*, *Schizostoma* can only be compared with Sowerby's genus. The typical species of *Schizostoma* is *Euomphalus catillus*, Sow., and on a first glance it is apparent that this species is distinct from *E. pentangulatus* by the presence of two keels, including between them the slightly convex periphery of the shell, and that it in this respect resembles very much those forms which have been considered as forming the genus *Discohelix* of Dunker. Stoliczka, however, has very rightly pointed out, that in *Discohelix* the striæ of growth on the convex periphery of the shell are bent backwards, whilst they are arched towards the front in *E. catillus*, and that thus this latter species is decidedly different from Dunker's genus. On the other hand, it is also different from the genus *Euomphalus* by the presence of two keels instead of one, which cause on the aperture of the shell two slight emarginations; the genus *Schizostoma* might thus be adopted on as good grounds as many other genera of fossil shells of which no living representative any longer exists. Species of *Schizostoma* have as yet been found exclusively in palæozoic formations.

The distinctive characters of *Discohelix* from *Schizostoma* have been already mentioned; they consist in the direction of the striæ of growth, which are bent backwards between the two keels on the periphery of the shell in *Discohelix*, whilst they form an arch directed towards the front in the same region of the shell in *Schizostoma*.

The genus *Maclurea*, Emmons, is very ill defined, founded chiefly on the strange development of its operculum, which certainly indicates a distinct genus, but which seems not to be accompanied by corresponding peculiarities of the shell.

Thus if the operculum is not preserved, the shells, which ought to be properly included in this genus, will be very easily mistaken for *Straparoli*.

Ophileta (Vanuxem), Hall, is even worse defined than *Maclurea*. The first species mentioned by Hall, and which, therefore, must be taken as characteristic, is *O. levata;* this is a discoidal shell, with numerous whorls and a keel on its lower surface. The specimen figured of this species is, however, very imperfect, and it remains to be decided whether the presence of a keel on the lower surface of the whorls is sufficient to distinguish the genus. The second species mentioned by Hall bears two keels, and is thus either a *Schizostoma* or a *Discohelix*, which of the two depends upon the direction of the striæ of growth, which have not been observed.

Of the genus *Euomphalus* there exist only two species in the palæozoic deposits of the Salt-range which I shall call *E. parvus*, W., and *E. pusillus*, W. In general form they agree with most of the species placed in this genus, being flat shells coiled nearly in one plane, with whorls barely touching each other, and bearing a sharp keel along their upper surface. There is, however, only one species with which the Salt-range forms can be more particularly compared; this is *E. similis*, Meek and Worthen, from the Saint Louis Limestone of Illinois. A more slight resemblance is also exhibited by *E. impressus*, Eichwald, from the carboniferous limestone of Borowitchi. There is no doubt that both the Indian species, as well as the American, are more or less allied to *E. pentangulatus*, Sow., and that they are a minute repetition of that species; but though this requires but little comment, yet it is very difficult to state in what sort of connection the English species may stand to the American and Indian forms. Principally it is barely possible to state with any exactitude which of the species is the geologically older one and which the more recent: only from the circumstance that *E. pentangulatus* has been quoted already from devonian strata, it may be guessed that this species is more ancient than *E. similis* and the other minute forms which I am about to describe from India.

On the other hand, if we take it as granted, that *Euomphalus pentangulatus* is the geologically oldest species of those which are more or less closely allied to the shells under consideration, it is barely possible to state if *E. similis* may have taken directly its origin from *E. pentangulatus* or not, as these shells are all so very rare, and their geographical distribution so very sporadic, that it seems not advisable to utter any definite opinion as to their developmental connection. Though it is pretty certain that the shells of the Gasteropoda are nearly as well adapted as the Cephalopoda to retain traces of the developmental changes time and circumstances have wrought on the animals by which they were once inhabited, yet it requires most ample materials to trace these minute differences within a series of fossils coming from several successive strata. But such materials are absolutely not obtainable in geologically older formations; for circumstances so favourable as exist, for instance, in the silurian basin of Bohemia, are extremely rare; and generally, in palæozoic as well as in mesozoic formations, localities rich in Gasteropoda are geographically and geologically far apart, and thus comparisons between the single faunas

become extremely difficult. Only in tertiary times the careful study of the Gasteropoda will bring about essential changes in general views regarding these formations; for it is certain that nothing but the most detailed observation of the developmental changes the single forms undergo in time will enable us at last to establish a definite geological classification of the tertiary rocks, which up to the present is arbitrary to a certain extent.

It is pretty certain that the two species described on the following pages take their origin one from the other, so that *E. parvus*, W., which occurs in the upper division of the Middle Productus-limestone, is to be considered as the parent form of *E. pusillus*, W., which is not very rare in the Upper Productus-limestone, but with these two links the chain is at an end, and it is impossible to state whether *E. similis*, M. and W., is to be considered as another link in the same.

In describing the Gasteropoda of the palæozoic deposits of the Salt-range, I shall, therefore, not be able to point out in every case the developmental group to which the species belongs as I have done in the Cephalopoda, but shall only discuss the developmental connection of the single forms under consideration as far as this seems possible.

1. Euomphalus parvus, Waagen, n. sp. Pl. IX, fig. 2.

All the specimens of this species I have got for description are of very small size, and it seems, therefore, probable that the species never attained more considerable dimensions.

The general form of the shell is flat disciform, the whorls are thin and very evolute, barely touching each other. The whole shell consists of about four whorls, which are entirely exposed, and bear on their upper surface a strong prominent rounded keel, which is accompanied on its outer side by a marked longitudinal depression or groove. The peripheral side of the whorls is rounded and prominent, but not limited at the sides by edges. The lower surface of the whorls is slightly angular, a nearly flat part of the shell sloping down from the indistinct edge towards the umbilicus.

The transverse section of the whorls is irregularly pentagonal, the outer angle of the pentagon being rounded, and its base very narrow and contracted. The two opposite lateral angles are not on a horizontal line, but the one corresponding with the upper surface of the shell lies much higher than the other.

The shell is not coiled entirely in one plane, but the lower or umbilical side is somewhat more excavated than the upper one; but on the upper side the sutures between the whorls are deeper sunk than on the lower side.

The whole surface of the shell is covered by strong prominent striæ of growth, which are, however, neither very numerous nor are they all equal in strength, but several thin ones are intercalated between two of the stronger sort. The striæ of growth are slightly undulating and bent backwards on the keel, or upper side of

the shell. They form an arch on the peripheral part of the whorls, and, turning again towards the front, reach the umbilical suture in an elegant falciform curve.

Though I have one of the specimens broken into pieces, no trace of any septa is observable.

The dimensions of the largest of the specimens at my disposal are as follows:—

	mm.
Diameter of the shell	9
„ umbilicus	4
Height of the last whorl at the aperture	2·5
Thickness „ „	3

Locality and geological position.—Altogether there were collected three specimens of this species by myself, one at Khúra in the compact limestones of the middle division of the Productus-limestone, and two others west of the same locality in marly beds in the upper region of the Middle Productus-limestone. The species thus seems to be restricted to the middle division of the Productus-limestone series.

Remarks.—This very pretty little shell bears a certain resemblance to many of the species of *Euomphalus*, and chiefly it seems to be a miniature copy of *E. pentangulatus*, Sow., but though this is the case, still the size of the shell is sufficient to distinguish the species. In *E. pentangulatus* a specimen having about four whorls exhibits a diameter of about 25 mm., whilst in our species specimens with an equal number of whorls attain not more than 9 mm. in extreme cases. The only species which agrees more or less, as well in its general form as in its size, with *E. parvus* is *E. similis*, Meek and Worthen. These authors distinguish two forms within the species, the one the typical *E. similis*, the other *E. similis* var. *planus*, which, according to their views, might as well be considered as a separate species under the name of *E. planus*. It is chiefly the latter form with which *E. parvus* might be compared; it has been figured and described in the Geological Survey of Illinois Vol. II, page 286, Plate XIX, fig. 5; and from this figure it is not very difficult to gather the points of dissimilarity between the American species and *E. parvus*. The chief difference between the two forms consists in the more rounded whorls of *E. planus*, and in the more flattened sutures on the upper surface of the shell. In *E. parvus*, on the contrary, the whorls bear on their upper surface a strong prominent keel, which causes a strongly angular section of the whorls, and from this keel the shell slopes rapidly down to the deeply set suture. On the lower surface of the shell the similarity of the two species is greater, but also here the rounded edge on the whorls lies more nearly inside towards the umbilicus in *E. parvus* than is the case in *E. planus*.

E. planus, M. and W., was described originally from the Saint Louis limestone of Illinois, and belongs, therefore, to the upper region of the mountain-limestone formation. This, however, throws but very little light on the age of the Indian species, as we do not know in what sense or direction the changes, wrought by time and circumstances, take place in the species of *Euomphalus*; and thus it is very

difficult to tell which of the two species may be the more recent, or by what space of time the two species may be separated from each other. From other characters, however, exhibited by the other fossils of the Productus-limestone, it is probable that *E. parvus*, W., is more recent than *E. planus*, M. and W.

2. Euomphalus pusillus, Waagen, n.sp. Pl. IX, fig. 3.

This species is, like the preceding one, of very small size, but bearing sufficiently distinct characters to warrant its separation as a well-defined species.

The general form of the shell is flat disciform with a very wide umbilicus, the whorls barely touching each other. The shell consists of about four whorls, which are very evolute and entirely exposed. They bear on their upper surface a low, obtuse keel, which forms an obtuse spiral edge along the suture of the whorl. From this keel the peripheral part of the whorls projects strongly in a perfectly rounded arch. Also on the lower or umbilical side of the shell a keel occurs, not so obtuse as the one on the upper side, but more angular and more prominent.

The transverse section of the whorls is approximately pentagonal, more regularly so than in the preceding species. The outer angle of the pentagon, corresponding with the peripheral part of the whorl, is broadly rounded off; the base is very narrow, and the two opposite lateral angles, corresponding to the lower and upper keels of the shell, are nearly on a horizontal line, whereby it appears that the two keels are exactly opposite each other.

The whorls are not coiled in one plane; the umbilical side of the shell is more excavated than the upper side. On both sides the sutures are about equally deeply set.

The surface of the whorls is covered by very fine narrow striæ of growth, slightly undulating and about equal in strength.

In none of the specimens received for description is there any trace of a septum observable.

The dimensions of the specimen figured on Plate IX are as follows:—

Diameter of the shell	8 mm.
„ „ umbilicus	4·5 „
Height of the last whorl at the aperture	2 „
Thickness „ „ „ „	2·5 „

Locality and geological position.—Altogether there have been collected by me two specimens of this species, one in the topmost beds of the Productus-limestone at Chidru, the other, which is only exposed at its lower surface, but which very likely also belongs to this species, at Jabi, in the identical bed from which I have also described the Cephalopoda: *Cyclolobus oldhami*, *Sageceras primas*, and *Xenodiscus carbonarius*, in the upper division of the Productus-limestone.

Remarks.—Though this species is very nearly related to the preceding one, yet there exist some very striking differences, which will be easily discovered in comparing the enlarged figures on Plate IX with one another. These differences consist chiefly in the sculpture of the two surfaces of the shell being different: whilst in *Euomphalus parvus*, W., the upper surface bears a strong prominent keel, which is accompanied on its outer side by a spiral impression or groove, this keel is low and obtuse in *Euomphalus pusillus*, W., and no groove is present. On the lower surface again the keel is low and very much approaches the umbilicus in *Euomphalus parvus*, whilst it is angular and prominent, and in its position about opposite the keel, on the upper surface in *E. pusillus*. The striæ of growth are comparatively strong and unequal in their development in *E. parvus*, and much finer and more equally strong in the species here under consideration. Thus, I think, it is justifiable to separate the two forms under distinct names.

As to the similarity of the present species to *Euomphalus pentangulatus*, Sow., the same differences exist as have been pointed out to obtain between Sowerby's species and *E. parvus*. Like the latter, *E. pusillus* is already distinguishable by its very reduced size, which is not more than 8 mm. in a specimen with four circuits, whilst of *E. pentangulatus* a specimen with the same number of whorls has already 25 mm. in diameter.

Of other species *E. planus*, M. and W., must be compared. The similarity of the American shell to *Euomph. pusillus* is very striking, and compared only from their lower surfaces these shells are not distinguishable at all. The upper surface of *E. planus*, however, bears a strongly marked angular keel, which is situated far towards the peripheral part of the shell, whilst this keel is broad and obtuse in *E. pusillus* and directly opposite the keel on the lower surface.

Euomphalus impressus, Eichwald, which bears also a certain resemblance to *E. pusillus*, is, however, much less nearly allied. Its whorls are higher and much more compressed, and its keels lying very far out towards the periphery of the shell so as to approach in its general form more or less the type of *Schizostoma*, Bronn.

Thus *E. pusillus*, W., seems to be a well distinguishable species which is, so far as known up to the present, characteristic to the upper division of the Productus-limestone of the Salt-range. It is probable from its similarity to *E. parvus*, W., and its position higher in the series than the latter species, that there exists a developemental connection between the two forms; but the materials at my disposal are so very scanty that it seems impossible to assert anything positively, or to draw any conclusion as to the tendency to variation prevailing among these species of *Euomphalus*.

Family: *EULIMIDÆ.*

Sub-Family: *CHEMNITZIINÆ.*

Genus: HOLOPELLA, M'Coy.

Though it seems not very difficult to distinguish the genus *Holopella* as composed of more or less turreted shells with particularly convex and prominent whorls, yet this distinction is not always equally easy, and chiefly for the species I shall have to describe it is very doubtful whether it ought to be considered as a *Chemnitzia* or as a *Holopella*.

According to the original definition of the genus as laid down by M'Coy, this seems in general related as well to *Chemnitzia* as to *Loxonema*. The distinctive characters from *Chemnitzia* consist, according to M'Coy, "in the smaller size of the body whorl and in neither it nor the mouth being produced anteally." From *Loxonema* it seems to differ by the absence of a prominent and easily discernible sculpture on the whorls, and by its mouth not being enlarged and prolonged anteriorly.

Stoliczka thinks it barely possible to distinguish *Loxonema* thoroughly from *Chemnitzia;* but I think the very peculiarly produced anterior part of the mouth, combined with more convex whorls, and a by far more slender spire, are characters sufficient to distinguish the genus *Loxonema* from *Chemnitzia*. *Holopella*, in its most characteristically developed species, is, according to Stoliczka, distinct from *Chemnitzia* by its more convex whorls and the absence of an insinuation on the posterior part of the outer lip of the aperture. To this can, I think, be added the shorter and more numerous whorls in *Holopella*.

The species which I shall have to describe, and to which I shall give the name of *H. trimorpha*, W., bears characters which equally well agree with *Chemnitzia* as with *Holopella*. Up to a length of the spire of 12mm. the whorls are smooth and flat, the suture which divides the whorls from each other being barely distinguishable. In somewhat larger specimens the whorls get more convex, but yet there is a flat zone along the posterior part of the whorl which recalls to a great extent the form of the whorls in *Chemnitzia*, where this more or less flattened zone corresponds approximately to the insinuation exhibited by the striæ of growth in the genus mentioned. Full-grown specimens of *H. trimorpha*, W., show entirely convex whorls like all other species of *Holopella*.

It is a fact worthy of notice that the different stages of growth in *Holopella trimorpha* correspond approximately with three different genera existing in the palæozoic series of rocks. We have there first the genus *Loxonema*, Phillips, which bears a slight insinuation on the posterior part of its outer lip very much like *Chemnitzia*, Orb., but which is distinct from the latter genus by the characters mentioned above; then comes the genus *Polyphemopsis*, Portlock, which is yet very

insufficiently known, but which seems to resemble *Chemnitzia*, differing only by the absence of an insinuation on the outer lip of the aperture; and at last there is *Holopella* with very short and convex whorls.

A very similar series of forms can be observed in mesozoic up to recent strata: *Loxonema* is here replaced by *Chemnitzia*, *Polyphemopsis* by *Pseudomelania*, Pict., and *Holopella* by *Dunkeria*, Carp., or *Hyala*, H. and A. Adams.

The fact that all three palæozoic genera are more or less clearly represented in different stages of growth of one and the same specimen of *H. trimorpha*, W., shows with absolute evidence how closely allied the three genera are. Nevertheless I do not think it advisable to unite under one and the same generic designation all those forms which have been up to the present considered to constitute three different genera; I think it rather much more probable that *H. trimorpha* must either be considered as a form produced under the influence of "atavism," or else the genera *Chemnitzia* and *Pseudomelania*, which appear in well-developed forms only later in the geological series, are foreshadowed in the species under consideration in its more juvenile stages of growth. The latter seems the more probable case, as will be seen from the following specific description of the shell.

1. Holopella trimorpha, Waagen, n. sp. Pl. X, figs. 2, 3.

The shell of this tolerably large species is very elongated, consisting of very numerous depressed whorls. Every trace of sculpture on the shell is absolutely wanting, and the striæ of growth are very indistinct. The shell is about six times as high as it is broad.

The different stages of growth are very distinct from each other, and must be described separately. The embryonal whorls are not preserved in any of the specimens received for description; but from the first volutions down to a height of the spire of about 12 mm. the shell can be observed in one specimen, and from this it can be stated that the whorls during all this length of the shell are perfectly flat on their outer side, the sutures between the single whorls being only so very slightly indicated that they are barely perceptible. The striæ of growth are very indistinct, but seem to be tolerably straight. From 12 mm. down to 23 mm. of the length, which distance includes, however, not more than three or four volutions, the surface of the whorls changes rather suddenly from flat to convex, a flat zone, however, remaining along the posterior margin of the whorls. It is not possible to observe whether the direction of the striæ of growth indicate any insinuation of the posterior part of the outer lip during that stage of the development of the shell; the existence of a flat zone, however, similar to that existing in most species of *Chemnitzia*, makes it probable that such an insinuation existed. After the shell has attained more than twenty-three millimeters in length the flat zone disappears and the whorls become regularly convex as in other species of *Holopella*.

The aperture of the shell is thoroughly entire, and no trace of any canal, or of its being effuse in any way on the anterior part, is observable. The posterior part of the aperture is angulated, the outer lip sharp, the inner one slightly thickened.

The measurements of a specimen from Chidru are as follows :—

Total length of shell about	27 mm.
Breadth at basis	4·5 „
Height of last volution	2·9 „
Apical angle of shell	12·5°

Another specimen (a cast), somewhat deformed by pressure, has an apical angle of 17°.

Locality and geological position.—Three specimens of *Holopella trimorpha* were collected by myself: two I found in the topmost beds of the Productus-limestone at Chidru, and the other west of Khura in the upper division of the Productus-limestone. The species seems thus to be restricted to the upper division of this formation.

Remarks.—As all the species of *Holopella* are deficient in marked distinctive characters, and as all the smooth forms specially more or less resemble each other, there might be a number of species compared to *H. trimorpha*. Yet the distinction of the species is not very difficult, on the one hand, because the number of smooth *Holopellæ* in upper palæozoic strata is very limited, on the other hand, because the form of the present species is rather peculiar. From the carboniferous formation only two species have been described under the generic designation of *Holopella;* there exist, however, a number of other forms, which have been referred to different genera, but which very likely also must be considered as *Holopellæ*. The species here described is, among all the forms which might be compared, the one which is most elongated in its general outline; only *Chemnitzia gracilis*, Kon., which is very likely also a *Holopella*, is even more elongated than our species, but it bears transverse ribs on its whorls, which are absent in *H. trimorpha*. Of American carboniferous species *Loxonema cerithiformis*, M. and W., might be compared, but its spiral is shorter and the striæ of growth bear a distinct insinuation.

The genus *Holopella* was very badly represented during permian times, nevertheless one species described from permian strata must be considered as belonging to the genus; this is *H. phillipsi*, Howse, sp. (*H. geinitziana*, King), a very small shell with smooth whorls, which is, however, easily distinguishable from the Indian species by its much shorter spire and more convex whorls. The same is the case with *Holopella gracilis*, Schaur., from the bunt-sandstein beds of the Alps, which, on the whole, is very nearly related to *H. phillipsi*.

The position of the species under consideration in the genus *Holopella* might be very much questioned; two genera may be quoted in which the species might be placed with nearly equal right; these are *Polyphemopsis* and *Chemnitzia*.

The first volutions of the shell, if separated, would be quite rightly placed in the first of those two genera, but the further development of the shell forbids such a determination, as the whorls then become too convex and too numerous to allow of the position of the species in the genus *Polyphemopsis*. In this stage of growth the shell resembles very much a *Chemnitzia*, but also for that genus the whorls are too numerous and too much shortened. Thus, as the genus which in most of its characters agrees with the shell under consideration, there remains only *Holopella*, and I have therefore placed the species in this latter genus.

Sub-Family: *STILIFERINÆ*.

Genus: MACROCHEILUS, Phillips.

Though this genus is one of those which is most easily to be recognised among all the genera of palæozoic gasteropoda, yet its position in the system is by no means certain, and as there is no hope of there ever being found any remains of the animal, this uncertainty is not likely ever to be removed.

The shells belonging to this genus exhibit a very characteristic form. They are more or less turreted, with tolerably elongated spire, not very numerous and moderately convex whorls. The aperture is elongated, anteriorly often slightly effuse, posteriorly angulated, the outer lip entire, the inner lip sometimes very slightly callous with a more or less strongly developed columellar fold near its anterior end.

What causes the uncertainty about the systematic position of the genus is its bearing sometimes an anteriorly slightly effuse aperture. Those authors who lay a greater stress on this peculiarity of the shell than on other characters, will place the genus among the *Siphonostomata* somewhere near *Pyramidella* or *Turbonilla*, whilst others, who prefer to classify the shells more according to their general appearance and not according to single not very prominently developed characters, consider it more prudent to retain the genus *Macrocheilus* in the *Holostomata*, and place it, as seems to me very rightly, together with *Stilifer* in the family of the *Eulimidæ*. I therefore in this respect entirely follow Dr. Stoliczka, whose system appears to be of all those proposed up to the present the most practicable one for the palæontologist.

The genus *Macrocheilus* seems to be represented by the greatest number of species during carboniferous times, but after that period the genus suddenly disappears[1] almost entirely, and in more recent formations only in the triassic beds of the Alps a couple of species of this genus have been noticed. From the palæozoic deposits of the Salt-range two species have been described by de Koninck: *Macrocheilus avellanoides*, Kon., and *M. depilis*, Kon. Of these two species only one was found, and in great numbers, by myself and Mr. Wynne in the

[1] King's *Macr. symmetricus* scarcely belongs to that genus.

palæozoic deposits of the Salt-range; the other species, *M. depilis*, in its general appearance, so very much resembles certain *casts* of gasteropods occurring in the higher beds of the Salt-range series, cretaceous and nummulitic, that I cannot but express the opinion that the shell in question is very likely not a *Macrocheilus*, and belongs probably to the fauna of the nummulitic strata; I shall therefore avoid mentioning it among the palæozoic fossils. The original specimen is, I regret to say, not among the materials preserved in the Geological Society's collection, but must have gone with the other part of Dr. Fleming's fossils to Calcutta, where it has apparently been lost. Thus this point cannot be settled definitively.

We have therefore only one species of *Macrocheilus* in the upper palæozoic strata of the Salt-range; this is *Macrocheilus avellanoides*, de Kon.

1. Macrocheilus avellanoides, de Koninck. Pl. IX, figs. 6-9.

1863. *Macrocheilus avellanoides*, de Koninck. Fossiles Paléozoiques de l'Inde, p. 13, Pl. IV, fig. 4.
1863. *Macroch. avellanoides*, Koninck. Quart. Journ. Geol. Soc. Lond., Vol. XIX, p. 10.
1878. *Buccinum incertum*, Abich. Geologische Forschungen in den Kaukasischen Landern.. I, Kohlenkalk-Fauna aus der Araxesenge von Djulfa, p. 82, Pl. XI, fig. 4.
1878. *Macrocheilus indeterm.*, Abich.. *ibid.*, explanation of Plate XI.

This species is one of the most characteristic fossils occurring in the Salt-range, as it is found nearly everywhere; and it keeps with great constancy to a certain geological position.

The general form of the shell is more or less elongate-ovate, the length of the spiral not very considerable, but variable, with a not very acute apex. The whorls are tolerably convex, but six or seven in number; the sutures separating them from each other are slightly excavated. The surface of the whorls is nearly quite smooth, barely any striæ of growth being observable. The last whorl is very large and occupies about two-thirds of the height of the whole shell.

The aperture is rather narrowly oval, angulated behind, and well rounded everywhere else. The outer lip is thin and acute, without callosity or anything of the kind; on the anterior part of the aperture it bends round in a narrow curve, giving thus to the latter the appearance of being slightly effuse. The inner lip is thicker than the outer one, but not callous, properly speaking; it is without edge, but well rounded, and bears on its anterior part before uniting with the outer lip a more or less strongly developed broad and not acute columellar fold.

This fold is very characteristic, but very differently developed in different specimens of the same species, and one needs only look at the figures of Plate IX to be convinced how very variable that character is.

The shell never attains a very considerable size. The largest specimen known to me is represented by a cast, which was collected by Mr. Wynne at Khund Ghât, and which has been figured on Plate IX, fig. 6. The size generally exhibited by the specimens is that of figs. 7 and 8 on Plate IX.

The measurements of three specimens, I and III from Khund Ghât, II from west of Khura, are as follows:—

	I. mm.	II. mm.	III. mm.
Total length of shell	40	39	30
Greatest breadth of shell	27	26	19
Height of the last volution of the aperture	27	25	21
Greatest breadth of the aperture	11	11	8
Apical angle	82°	82°	87°

The apical angle decreases with the progressing age of the specimens.

Locality and geological position.—There are altogether more than forty specimens of *Macr. avellanoides* in the collection received for description; and it appears from this, that it is one of the most common species of Gastropoda existing in the palæozoic deposits of the Salt-range. Of the whole lot there were found 18 at Katwâhi in the upper division of the Productus-limestone, 20 at Khund Ghât in the same beds, 3 at Kufri in the division No. 14 of the section there (upper Productus-limestone), 3 west of Khura, 2 at Chidru in the Cephalopoda bed, 1 at Jabi, also in the Cephalopoda bed, the three latter localities being also in the upper Productus-limestone; and finally one specimen in a bed of crinoidal limestone at Virgal belonging to the middle division of the Productus-limestone, and two specimens at Bilot (Trans-Indus), also in the middle division of the Productus-limestone. Thus the species commences, as far as known up to the present, in the middle division of the Productus-limestone, and has its chief development in the upper division of the same formation.

Remarks.—It is very difficult in the genus *Macrocheilus* to decide what ought to be considered as separate species, as such a number of forms exist which more or less resemble each other that distinction is rather difficult.

In the description of the species Mons. de Koninck compares the form under consideration to *Macr. schlotheimi*, d'Arch., from devonian strata, but says that it differs from it by the angle of its spiral, by the length of the last volution, and by the absence of every kind of ornamentation on its surface.

During carboniferous times several species existed, having a more or less close resemblance to the present species. There are three shells from the Russian mountain-limestone to be compared: *Macr. affinis*, Eichw., from the lower mountain-limestone of the Gouvernement Tula, *Macr. lævis*, Eichw., and *Macr. ampullaceus*, Fisch., the two latter from the upper mountain-limestone of Miatchkowa. The first of the three seems to be more closely allied, but the larger size of the shell, more strongly inflated whorls, and an impression the shell bears on them, seem to warrant a distinction; the two latter are very likely identical, and are distinguishable from de Koninck's species by a much shorter spire and by far more inflated whorls.

The greatest resemblance to the Indian shell is exhibited by an American species which has been described by Meek and Worthen from upper coal-measures

of Illinois. This is *Macr. medialis*, M. and W. The general form of both shells is very similar indeed, and the chief difference between the two seems to consist in the by far more considerable size the Indian shell attains. Of other characters the somewhat greater inflation of the whorls in *M. medialis* and a differently shaped aperture must be mentioned, though the latter peculiarity is not trustworthy, as Meek and Worthen mention in the text that the figure showing the aperture of *M. medialis* had not been drawn quite correctly.

Thus the possibility remains that *M. avellanoides*, Kon., and *M. medialis*, M. and W., may be identical, yet the great geographical distance at which the two species occur seems not to be in favour of such a supposition, and the small differences mentioned may thus be considered sufficient to distinguish these shells under separate names.

A species which must be united beyond any doubt with *M. avellanoides*, K., is *Buccinum incertum* or *Macrocheilus ind.* of Abich. Though of this species only a cast has been found up to the present, yet this agrees so well in every respect with the casts of *M. avellanoides* preserved in the Salt-range collection that there is no chance of any distinction. The locality at which this cast was found is Djulfa on the Araxes, in strata which were considered by Staatsrath Abich as representing the upper mountain-limestone, but which are considered by Professor Möller to belong to the permian formation.

Family: *NATICIDÆ.*

Sub-family: *NATICINÆ.*

Genus: NATICOPSIS, M'Coy.

Though the shells belonging to this genus have been for a long time simply included in the genus *Natica*, yet it seems that the relation between the two genera *Natica* and *Naticopsis* is not so very close; and Meek and Worthen in their geology of Illinois, in pointing out the peculiarities existing in the operculum of *Naticopsis*, are of opinion that the genus ought to be considered as the type of an extinct family, the *Naticopsidæ*.

If, however, the operculum be not preserved, and one have to rely solely on the general form of the shell, the differences are not so very striking, and the general resemblance of *Naticopsis* to *Natica* is obvious. Thus, I think, the genus might very well be included in the *Naticidæ*, and it cannot be very wrong to follow in this case also Dr. Stoliczka.

The diagnosis of the genus originally given by M'Coy is very short, but quite sufficient to fix the genus. Some stress, I think, must be put on the words "inner lip smooth, flattened, slightly thickened." This circumstance—the inner lip being only slightly thickened—will alone enable us to distinguish between the species

belonging to *Naticopsis* and those which might better be put into the genus *Ampullina*, and which otherwise bear a great resemblance to *Naticopsis*, but differ from it by the very strong callosity developed on their inner lip. Thus we will easily be able to retain the genus *Naticopsis* as a very well characterised group of forms which cannot easily be confounded with the *Ampullinæ*. Besides the differences in the shell, there seems also to exist for the two genera a somewhat different geological distribution. Whilst the genus *Ampullina* seems to be chiefly numerous in the middle and upper mesozoic formations, the genus *Naticopsis* seems to prevail in numbers chiefly in palæozoic strata, growing more and more scarce as it proceeds into newer formations.

In accepting the genus *Naticopsis*, it is necessary to recur to the first definition of it by M'Coy, in his "Carboniferous fossils of Ireland." The first species named there is *N. canaliculata*, M'Coy, a species with very thin shell and having the sutures of the volutions deeply sunken in. Later on, in the "Palæozoic Fossils," M'Coy has laid great stress on the flattened condition of the inner lip which the species belonging to the genus ought to exhibit; but neither in M'Coy's first named species, nor in other typical forms of the genus, does this character seem to be conspicuous. Other species, indeed, which have been put by M'Coy into his genus, as *Nerita ampliata*, Phill., &c., show this flattening of the inner lip in a remarkable manner; but they very likely, on account of this character as well as on that of the very thick and compact shell they possess, must be removed from the genus and be placed more near the *Neritidæ* than near the *Naticidæ*.

Among the materials collected in the Salt-range there are only two species belonging to the genus, which, however, do not bear a very great resemblance to each other, and can, therefore, scarcely be considered as in developmental connection, though both occur in successive strata. The older of the two was found in the upper region of the middle Productus-limestone at Khura, the other comes from the upper Productus-limestone at Khund Ghât. One of them resembles triassic, the other carboniferous, species.

1. NATICOPSIS KHURENSIS, Waagen, n. sp. Pl. IX, fig. 10.

There is only one specimen of this species in the Salt-range collection, but it is well preserved and allows of accurate description.

The general form of the shell is globose, a little higher than broad, with a short or scarcely elevated spire. The whorls are not numerous, altogether about three; they are very inflated, prominently convex and not entirely enveloping each other. The exposed part of the inner whorls is convex, and in consequence of this the sutures between the whorls somewhat impressed. The last whorl is the largest, higher than broad, without a trace of an umbilicus at its base.

The embryonal part of the shell is not observable.

The shell is thin, only somewhat thickened at the lower or basal part of the

specimen. The surface of the shell is smooth to all appearance; with the lens, however, numerous very fine striæ of growth are observable. These are sharp and more closely arranged near the aperture than on the parts of the shell removed from it.

The aperture is ovate, angulate behind, perfectly round in front. The outer lip is sharp and thin, the inner one is rather straight and slightly thickened, without any distinct callous part. Both lips unite anteriorly in a slightly prominent angular shelly part (fig. 10 *d*), which gives a strange character to the whole form of the aperture and makes it appear somewhat effuse anteriorly.

The measurements of the specimen described above are as follows:—

Total length of shell	33 mm.
Greatest breadth of shell	30 „
Height of last volution at the aperture	30 „
Breadth of the aperture	20 „
Apical angle	116°

Locality and geological position.—The only specimen of this species preserved in the Salt-range collection was found by myself in beds at the upper limit of the middle Productus-limestone west of Khura.

Remarks.—There are not a great number of species which can be compared to the shell just described. Among European palæozoic fossils the only species to which it can be compared is *Nat. plicistria*, Phill., from the mountain-limestone of Yorkshire. This species can, however, be distinguished from the Indian fossil by its less globose form and by its thick heavy shell.

Two other forms to be compared, and which of all bear the greatest resemblance to the shell here described, are *Nat. gaillardoti*, Lefroy, and *Nat. simlaensis*, Gümb. The former has a more depressed spire than *Nat. khurensis*, but *Nat. simlaensis* can only be distinguished by the more flattened sutural part of the whorls. *Nat. gaillardoti* is one of the most characteristic fossils of the lower and middle triassic beds of Europe, but it occurs in company with *Nat. simlaensis* in the Himalaya in beds of similar age.

The affinity of the shell under consideration to two triassic shells is of very great interest. This affinity is rather striking, and it seems not improbable that the triassic shells may have taken their origin from the species here described. From this a migration of shells at the close of the palæozoic epoch from India to Europe would result, which, on the whole, seems not improbable.

2. Naticopsis indica, Waagen, n. sp. Pl. X, fig. 4.

Like the preceding species, this one also is represented only by a single specimen.

The general form of the shell is inflated-ovate, higher than broad. The shell consists of about three rapidly increasing whorls, which almost entirely envelope

each other. The spire is very short and consequently the exposed part of the inner volutions very small. The latter is rather flattened, and thus the sutures between the whorls are flat and more or less indistinct. The last volution is not much more inflated than the preceding ones.

The shell is not very thick and exhibits a smooth surface, only with the lens fine striæ of growth are observable.

The aperture is ovate in form, acutely angular on its posterior end and broadly rounded in front. The external lip is thin and sharp, the inner one with a slight, distinctly limited callosity. Both lips unite at the anterior end of the aperture without forming an angle, which latter is the case in the preceding species.

It is rather difficult to take the measurements, as the specimen is not very well preserved, but, on the whole, they seem to be as follows:—

Total length of shell	40·5 mm.
Greatest breadth of shell	33 „
Height of the last volution at the aperture	35 „
Breadth of the aperture	23 „
Apical angle about	112°

Locality and geological position.—The only specimen of this species in the Salt-range collection was found by Mr. Wynne at Khund Ghât accompanying the *Nautili* and *Xenodisci* described above, and found there in the Upper Productus-limestone, group No. 1 of the list, p. 8.

Remarks.—Like the preceding one this species also can be compared to an European form, but in this case, the affinity is so great that it nearly amounts to specific identity. The fossil which resembles so very much the Indian shell is *Nat. phillipsi*, M'Coy, from the carboniferous limestone (lower part, mountain-limestone) of Ireland. The general form of the shells agrees almost perfectly, and the only character which immediately strikes the observer as establishing a difference between the two is the by far more considerable size attained by the Irish species. Nevertheless it seems not advisable to unite the two forms, as on a closer examination there appear to exist some other points of difference in favor of a distinction. Chiefly, M'Coy considers his species as probably identical with *Nat. elliptica*, Phill., from the mountain-limestone of Yorkshire. Now, *Nat. elliptica* is very different: the spire is much shorter and the last whorl much more inflated. If, therefore, *Nat. phillipsi* resembles so very much *Nat. elliptica* that both might be considered identical, the former cannot be so very closely related to *Nat. indica* as to warrant a specific identification. On the other hand also, M'Coy mentions some characters in his *Nat. phillipsi* which are absent in *Nat. indica*: thus, a well marked striation near the suture and a perfectly smooth surface on the other part of the shell.

Thus, if we take all these points into consideration, we shall be justified in distinguishing *Nat. indica* as a separate species, characterised by smaller size,

less inflated last whorl, and the absence of sharp striæ near the suture in distinction from *Nat. phillipsi*, M'Coy.

Though thus a specific distinction seems to be established, yet the great similarity of the two forms is very remarkable. *Nat. phillipsi* occurs in Ireland at Kilcommock and Longford in the lower division of the mountain-limestone, and at Stream-hill and Doneraile in the upper division of the same formation, but it seems to be absent in the middle division. There is no doubt that the Productus-limestone of the Salt-range is more recent than all the divisions of the true mountain-limestone as they are known to exist in England, Ireland, or Belgium. Thus it might very well be the case, that *Nat. indica* has taken its origin from the Irish fossil, and both thus may be in a developmental connection; but who, relying only on such isolated data, would venture to assert this and to draw any conclusion from it? The only thing that can possibly be done is, to call attention to such facts, and to let them accumulate; only in such a way at last results will be arrived at.

Family: *VELUTINIDÆ*.

Genus: PLATYSTOMA, Conrad.

There is a great number of fossil shells which have by former writers been called in a general way *Natica*, and which all exhibit more or less a globular form of shell and strongly inflated whorls. Though on a first glance it appears evident that very different things have thus been united, yet the exact limits between the several groups of forms seem very difficult to trace, and even a greater difficulty is experienced if we attempt to distribute them among the families and genera distinguished among recent mollusca. This is nothing but natural. If the families and genera of the mollusca as they exist now are the result of a historical process, and have been arrived at only by a long chain of transformations, they will not always have existed in the same shape as they present in our days, but things which now appear widely separated will, in former periods, more or less blend together, and thus the further we go back in the scale of formations, the more difficult it will be to assign the shells we find there to the recent genera and families. But though this is the case, yet we cannot avoid bringing those shells more or less into connection with the living ones; such a comparison must, however, only be taken for what it is worth, and it must be borne in mind that, as the animals of the fossil species will never be accessible to our observation, we must solely rely on the similarity of the shells, which may often be misleading. Thus if we venture to assign one or other of the palæozoic gasteropoda to a now living genus or family, nothing but the similarity of these shells to the recent forms can be expected by such a designation.

There is no doubt that a great many of those fossil shells which have been called *Natica* bear a very great resemblance to the living genus *Velutina;* and if

we wish to designate those forms among recent shells with which the fossil ones most nearly agree, we always will have to fall back on that genus; but then it is by far the simplest way to designate both by the same name, and to put the fossil shells into the genus *Velutina*, or at least into the family *Velutinidæ*.

The genus *Velutina* is chiefly characterised by few strongly inflated whorls, a short spire, and in consequence of this a more or less globular form of the shell. It is distinct from most of the *Naticidæ* by its very thin shell and the absence of any callosity on the inner lip of the aperture. Recent species can thus easily be recognised, not so the fossil ones. Chiefly in palæozoic formations there are a great many shells which resemble *Velutina* more or less, but which at the same time show a gradual transition to the *Capulidæ*, in such a manner that it becomes exceedingly difficult to decide whether some of the forms ought to be placed better in the one family or in the other. There is no hope of escaping the difficulty; we can only say that those forms with a very much enlarged aperture and a very little developed spire will be better placed in the *Capulidæ*, whilst others, in which the spire is more distinctly developed and somewhat elevated, and the last whorl is not out of proportion larger than the preceding ones, will have to be transferred to the *Velutinidæ;* but the similarity remains, and it is probable that the *Velutinidæ* have taken their origin from the *Capulidæ* during older palæozoic times.

Defined as I have just indicated, the *Velutinidæ* comprise a number of forms, some of which have received separate generic designations. The greatest development of the family seems to take place in older mesozoic strata, but though some of the forms occurring there closely resemble the true *Velutinæ*, others very likely will constitute separate and new genera. In palæozoic times the true *Velutinæ* seem to be scarce; they are replaced here mostly by allied forms, which, however, by their very short spire and somewhat expanded mouth, to a certain extent recall some forms of the *Capulidæ*, and in fact seem to constitute a transitional link between the two families. These forms have been united by Conrad under the generic name of *Platystoma*. *Platystoma*, like *Velutina*, is characterised by a thin shell, the spire, if very short, consisting of very few strongly inflated volutions, the aperture is very wide and oblique, outer lip sharp, inner one slightly thickened without callosity. The striæ of growth show in some species a bend, suggestive of a slight insinuation of the outer lip. Stoliczka expresses some doubt as to the propriety of separating these shells generically from *Velutina*, but by the characters mentioned above, they are pretty well removed from the *Velutinæ*, and approach more or less the *Capulidæ* and chiefly the genus *Platyceras;* thus it seems not improbable that also a generic difference exists between these shells.

Among the Salt-range fossils there is a single specimen of a shell which by its principal characters resembles *Platystoma*, and thus has been referred by me to that genus.

1. PLATYSTOMA INDICUM, Waagen, n. sp. Pl. XI, fig. 1.

The only specimen of this species in the Salt-range collection consists in an internal cast on which parts of the shell are still preserved.

The general form of the shell is oval, broader than high. The whole shell consists of three rapidly increasing inflated whorls, of which the last is by far the largest. The spire is very short and the whorls but little elevated; they are perfectly rounded without any trace of ornamentation. The shell is very thin and smooth, except some very fine striæ of growth, which are, however, barely visible, and the general direction and shape of which could not be ascertained. The aperture is very wide and somewhat expanded and very oblique in its position. The external lip is sharp and entire, without insinuation, the internal one is thickened and firmly adhering to the solid columella. Both lips unite anteriorly in a broad arch, posteriorly they form an obtuse angle.

Owing to some injury the animal received during lifetime, the specimen under consideration is not quite regularly developed; a short distance from the aperture near the suture a prominence has been formed, and from there the whorl deviates from the regular spiral (fig. 1 *d*).

The dimensions of the specimen here described are as follows:—

Total length of shell	40 mm.
Greatest breadth of shell	56 „
Height of last volution at the aperture	37 „
Breadth of aperture	35 „
Apical angle	138°

Locality and geological position.—The only specimen preserved in the Salt-range collection was found by myself in the Chittawán near Ghari, in a compact limestone, in the upper region of the middle division of the Productus-limestone.

Remarks.—Though the direction of the striæ of growth cannot be observed in this single specimen of the species, and though there seems to exist no insinuation or emargination on the outer lip, yet the species agrees in all other respects so well with Conrad's genus that it seemed best to quote this specimen as species of *Platystoma*.

The genus *Platystoma* seems to have chiefly a westerly distribution; and in the devonian as well as in the carboniferous epochs no European species of the genus have as yet been described, though it seems very probable that it will be found also in European strata.

In the carboniferous period two species have been recognised in America, both belonging to the upper coal-measures. They are *Pl. peoriense*, McChesn., and *Pl. tumidum*, M. and W., but neither of them seems to resemble closely the Indian fossil.

Sub-order: *SCUTIBRANCHIATA.*

Tribe: **PLANILABIATA.**

Family: *NERITIDÆ.*

Genus: NERITOMOPSIS, Waagen, n. gen.

Even in a higher degree than was the case with the preceding genus, the remarks made in the Introduction to the genus *Platystoma* apply to this genus. Nothing can be more difficult than to indicate the systematic place of the shells I designate under the name of *Neritomopsis*, and I have as much hesitation in introducing the new generic designation as in placing the new genus in the family *Neritidæ*.

The shells here under consideration have, moreover, been mostly described by former writers as species of *Natica*, while some have proposed to unite them with the genus *Nerita*; this division of opinion about the same species sufficiently indicates the difficulty which has to be overcome.

When M'Coy established his genus *Naticopsis*, he apparently united those doubtful species with it; but as the first species he quotes is *Nat. canaliculata*, M'Coy, a species with very thin shell and an inner lip which is not flattened, the name *Naticopsis* must be restricted to thinly shelled forms with slightly thickened inner lip, which, on the one hand, are barely distinguishable from *Ampullina*, and, on the other, show a certain transition to the *Velutinidæ*, chiefly to *Velutina* and *Platystoma*. Other forms with heavier shells and a distinctly flattened inner lip must be separated from M'Coy's genus, and constitute a distinct group for which I propose to introduce the generic name of *Neritomopsis*.

The genus is characterised by a globular form of the shell, a short spire and few very much inflated whorls. The shell is not very thin, the aperture entire, rounded in front, angular behind; the outer lip is sharp and entire, the inner one thickened, rarely callous, considerably flattened, smooth, without teeth or folds, generally adhering to the columella. Columella solid, not excavated.

The genus which seems to be most nearly related to the one here described is *Neritoma*, Morris, both genera being chiefly distinct by the outer lip being entire in *Neritomopsis*, whilst it bears an insinuation in *Neritoma*. Very nearly allied is also the genus *Naticodon*, Ryckh.; and indeed, some of the forms considered by Ryckholt to belong to his genus seem possibly better placed in *Neritomopsis*. There is not the slighest doubt, that in those species which I am here about to describe, the tooth on the inner lip, characteristic of the genus *Naticodon*, is not present.

What seems to be most doubtful is the systematic position of the genus. There seems to be a perfect transition from *Naticopsis* to *Neritomopsis*, and there is no doubt that both genera are most nearly related; but whether the two genera ought to form a proper family "*Naticopsidæ*" and represent a transitional link

between the *Naticidæ* and the *Neritidæ*, or whether, as I have done, the genus *Naticopsis* had better be placed in the *Naticidæ* and *Neritomopsis* in the *Neritidæ*, I must leave to be decided by further enquiries. So much, however, is certain, that the remarkably flattened inner lip of *Neritomopsis* establishes a close relation of the genus to the *Neritidæ*, and that thus the origin of the *Neritidæ* may very likely be traced from this genus.

The genus has its greatest development during palæozoic times, and seems to decrease in numbers in mesozoic strata. In the Salt-range it is represented by two species, *Neritomops. minuta*, Waagen, and *Neritomops. ovulum*, Waagen, which both occur in the upper division of the Productus-limestone.

1. Neritomopsis minuta, Waagen, n. sp. Pl. X, fig. 5.

Only one well preserved specimen of this species is contained in the Salt-range collection.

The general form of the shell is compressed globular, the side of the aperture being considerably flattened. The spire is very short, the volutions inflated, but indistinctly separated from each other, inner volutions not prominent, the last one very much larger than the others, prominently inflated. The shell is not very thick, smooth, only with the lens some very fine straight striæ of growth are observable. The aperture is wide semilunar, anteriorly rounded, posteriorly angular. The outer lip is sharp and thin, continuous, straight. The inner lip is somewhat thickened, considerably flattened, obtusely sharpened within, firmly adhering to the columella. Columella solid; no slit or any trace of an umbilicus existing.

The dimensions of the specimen are as follows:—

Total length of shell	6	mm.
Greatest breadth of shell	5·5	„
Height of last volution at the aperture	4	„
Breadth of the aperture	3	„
Apical angle	95°	

Locality and geological position.—The only specimen of this species was collected by myself at Chidru in the topmost beds of the Productus-limestone.

Remarks.—A very strange and remarkable feature of this species is the indistinctness of the single volutions. In this respect the shell resembles somewhat some of the *Umboniidæ*, with their smooth and polished shells. But as it could not be made out with absolute certainty whether this indistinctness of the volutions is an original feature, or whether this has been caused solely by the mode of preservation and by the changes the shell has undergone in the process of fossilization (having been transformed into calc-spar), no great stress has been laid in the description of the shell on this feature. If it is an original one, the animal must have possessed some lobes on the mantle which enveloped the whole shell.

The only species to which the Indian shell can be compared is *Nat. variata*, Phill. It is not improbable that this species also must be considered as belonging to the genus *Neritomopsis*. Ryckholt indicates a rudimentary tooth in some specimens he observed, but as I have no specimen from Bolland for examination, I must leave this question open. Specifically it is distinguishable from the Indian fossil by its less inflated whorls and by the fine spiral striation on the surface of the shell. The Indian specimen is, however, not sufficiently well preserved to admit of its being positively stated that it never possessed traces of such a striation, and thus both species might be in tolerably close relation.

Nat. variata, Phill., was described originally from the mountain-limestone of Bolland, but is there of very rare occurrence.

2. Neritomopsis ovulum, Waagen, n. sp. Pl. XII, fig. 4.

This species also is represented by a single specimen in the Salt-range collection.

The general form of the shell is ovate, considerably higher than broad. The spire is very short, the whorls are about three in number, inflated and perfectly rounded, the last of them is the largest, but not very much larger than the preceding ones. The sutures are indistinct, and the whorls not projecting above them. The shell is not very thick, smooth, barely any striæ of growth visible. The aperture is oval, rounded in front, and angular behind. The external lip is sharp and entire, the inner one thickened, slightly callous and considerably flattened, but not sharpened within, adhering firmly to the columella. The latter is perfectly solid.

The measurements of the specimen are as follows :—

Total length of shell	16 mm.
Greatest breadth of shell	14 „
Height of the last whorl at the aperture	14 „
Breadth of the aperture	8·5 „
Apical angle	130°

Locality and geological position.—The only specimen of this species preserved in the Salt-range collection was found by myself at Kufri, at the base of the section there, in the upper division of the Productus-limestone.

Remarks.—As in the preceding species so in this one, the sutures of the single volutions are not traceable. But in this case it is evident that the apical region is not well preserved, which may account for that peculiarity.

The species is certainly most nearly related to *Neritomops. minuta*, W., but can be distinguished from it by a somewhat less globular form of the shell, less inflated whorls, and an inner lip of the aperture which is not so much flattened as in *N. minuta*, and bears a slight callosity. The apical angle is also somewhat greater in the present species.

The resemblance of *Neritomops. ovulum*, W., to *N. variata*, Phill., is much less striking than that of the latter species to *N. minuta*, W. About the same characters which distinguish *N. ovulum* from *N. minuta* apply also to the distinction of the former species from *N. variata*, Phill., and besides this the presence of a spiral sculpture in the latter makes the distinctness of both forms evident.

Tribe: CILIIPEDATA.

Family: *TURBINIDÆ*.

Sub-Family: *PHASIANELLINÆ*.

Genus: PHASIANELLA, Lamk.

There occur not very rarely in the sandy beds at the top of the palæozoic series in the Salt-range small shining smooth shells, mostly well preserved in every way, the determination of which has been a very great puzzle to me. The polished surface of the shell, which is even in the fossil state tolerably well preserved, leads me to consider these little specimens as belonging to the *Phasianellidæ*, though the form of these minute shells is very much inflated and an operculum has not been observed. They cannot belong to the *Umboniidæ*, as every trace of a callosity on the inner lip is absent.

The inflated form of the shells and their very reduced size recalls to a certain extent some forms included in the genus *Tricolia*, Risso, but as Stoliczka also considers this genus only as a sub-genus of *Phasianella*, I may be justified in putting these shells into the latter genus.

In general form these shells recall also certain forms of the *Littorinidæ*, chiefly the *Lacuninæ*, but these have a hollow columella, and also the polished surface of the shells here under consideration is not in accordance with the characters prevailing in the shells of the *Littorinidæ*.

Species of the genus *Phasianella* have up to the present only rarely been recorded to occur in palæozoic strata. There are a number of species in the devonian period; but in carboniferous times there seem to have been described up to the present only two species, one by Koninck as *Chemnitzia ventricosa*, which has been transferred by Orbigny to the genus *Phasianella* as *Ph. subventricosa*, Orb., and another, according to Bigsby's Thesaurus, by Eichwald.

Only in mesozoic times the *Phasianellæ* become more numerous, and in the present period they are spread all over the tropical and subtropical seas.

1. PHASIANELLA ARENICOLA, Waagen, n. sp. Plate X, fig. 6.

The general form of this little shell is globular, with very short spire, consisting of three or four inflated rapidly increasing whorls. The exposed part of the

inner whorls is not convex; the last whorl is very much larger than the preceding ones, and envelopes the latter almost completely. The sutures, separating the single whorls, are well traceable, flat, and not impressed.

The shell is not very thick, with a perfectly polished surface; even with the lens barely any striæ of growth are distinctly perceptible. Where they can be traced, they are perfectly straight.

The aperture is oval, broadly rounded in front, and rather acutely angular behind. The outer lip is sharp and entire, the inner one very slightly thickened, but not callous, without folds or teeth.

The columella is solid, and thus the base of the shell not umbilicated, nor impressed, nor grooved.

The dimensions of a specimen from Chidru are as follows:—

Total length of shell	5 mm.
Greatest breadth of shell	5 „
Height of the last volution at the aperture	4 „
Breadth of the aperture	3 „
Apical angle	88°

The species does not seem to exceed the size of the measured specimen, as there are no larger ones in the collection.

Locality and geological position.—This species is not very rare in the palæozoic deposits of the Salt-range, but is there restricted to the upper division of the Productus-limestone. It occurs chiefly in sandy strata, and is therefore most numerously found in the white sandstones which form the very top beds of the formation; from the smallness of the shell, it would, however, be most easily overlooked, and thus it might be represented in other strata of the Productus-limestone, but have been passed over unnoticed. Four specimens were found by me in the strata indicated above at Chidru; and two have been chiselled out in cleaning a specimen of *Bellerophon* collected by Mr. Wynne at Khund Ghât.

Remarks.—As the species under consideration resembles in its general form more a *Naticopsis* than a *Phasianella*, and only seems to be essentially different from that genus by the polished surface of the shell and the flattened (not convex) whorls, there have not only the species of *Phasianella* hitherto described to be compared with our shell, but also among the *Naticopsis* and *Littorinæ* there might be species which would bear more or less of resemblance to *Phas. arenicola*.

There is only a single shell to which the present species bears a close resemblance, this is *Littorina pusilla*, M'Coy, from the mountain-limestone of Ireland.[1] This is also a very small species, only 6 mm. in length, is also perfectly smooth, and consisting only of three whorls, but the spire is much more elevated, and the whorls less inflated, and thus it is certainly different from *Phas. arenicola*, even if it should be ascertained that the Irish shell also bears a polished surface.

[1] It cannot be found out what special position the species occupies in Irelaud, as it does not occur in Griffith's tables; these, however, mention two *Littorinæ* from the millstone-grit which are not described in the text; is one of these identical with *L. pusilla ?* or are both ? None of the three names appears in Bigsby's Thesaurus.

Of other species only *Nat. uralica*, Eichwald, can in its general form be compared to our species; but the shell seems to have an umbilicus, and thus, apparently, the resemblance is only a very superficial one.

In American carboniferous or permian strata there is no species known to me which could be compared to *Phas. arenicola*, W.

Family: *TROCHIDÆ.*

Sub-Family: *MARGARITINÆ.*

Genus: MARGARITA, Leach.

Though Professor Meek has recently expressed the opinion, that the genus *Margarita* would not date back further than the cretaceous period, yet the shell which I have figured on Plate XI, fig. 2, cannot possibly, I think, be determined otherwise than as a true *Margarita;* and thus, from this fact alone, it is evident how very little we as yet have been able to trace out the developmental history of the Gasteropoda, as by the detection of the Indian species the origin of the genus would already date very far back, and reach down to the later palæozoic epochs.

The genus *Margarita* is easily recognisable by its thin shell (in the figures Plate XI, the shell has been drawn by far too thick), smooth or very finely striated whorls, nearly circular aperture, and an excavated columella, which is not surrounded by a crenulated margin. The nacreous condition of the shell can only rarely be observed in fossil species.

Nearly all the *Margaritæ* are very small shells, and only one doubtful specimen has been found by me which is somewhat larger than the one figured. Most of the recent species inhabit the sea-shores, but these generally are found in cold climates. It is of interest to mark this, as the occurrence of such a northerly type in the Salt-range deposits might possibly be of some use in the determination of the physical conditions prevailing at the time of deposition of the strata in which they occur.

Only one species of the genus occurs in the Salt-range, but this is not very rare, and has been found in several localities in the upper division of the Productus-limestone.

1. MARGARITA PRISCA, Waagen, n. sp. Pl. XI, fig. 2.

The general form of the shell is depressed conical; spire tolerably short, consisting of four not very rapidly increasing roundish whorls. The shell is thin and fragile, covered with numerous striæ of growth, which form a kind of very fine plication near the suture; they run from there in a straight line across the sides of the whorls and disappear at the base of the shell within the deep and narrow umbilicus, without forming any kind of crenulation on the edge of it. The sutures are

deeply impressed, and the whorls projecting in a low arch above them. The transverse section of the whorls is not quite round, but forms a kind of pentagon with rounded corners. The base of the shell slopes from the edge of the umbilicus down towards the outer margin of the whorl, and forms there a very obtuse barely perceptible edge; from there the wall of the whorl ascends in a regular arch to the suture. The aperture is not very well preserved, the margins being greatly broken and splintered, but the general form of it can be well observed. It is obviously pentangular, the lips being perfectly continuous, not being effuse anteriorly. The lips seem to have been nowhere considerably thickened, and even the inner lip shows no sign of any thickening. The columella is strongly and deeply excavated, forming a deep and narrow umbilicus, surrounded by a distinct, but not sharp edge.

The measurements of the figured specimen of this species are as follows:—

Total length of the shell	6	mm.
Greatest breadth of the shell	6	„
Height of the last whorl at the aperture	4	„
Breadth of the aperture	3·5	„
Apical angle	100°	

The largest specimen in the collection has 8 mm. in height.

Locality and geological position.—This little species is not very rare in the Salt-range. Three specimens were collected by myself at Virgal in the very top beds of the Productus-limestone formation; another somewhat larger specimen was found on the road from Katwáhi to Sháhpur, in the same bed which furnished the specimen of *Naut. goliathus*, W. Mr. Wynne collected two specimens of the same species also near Katwáhi, apparently in the upper division of the Productus-limestone.

Remarks.—This very remarkable little shell is of great interest, on the one hand, because it agrees so well in a general way with some much more recent forms of the same genus, on the other hand, because the habitat of the recent species of *Margaritæ* is tolerably limited, most of the species occurring near the shores of northern seas. We therefore might deduce from the not very rare occurrence of these shells in the Salt-range deposits, that the latter were formed near the shore in shallow water, and that the temperature of the sea must have been moderate.

There is no shell known to me in palæozoic deposits which could be closely compared to the one here described, though some may have a certain general resemblance. There is, for instance, *Trochus tulensis*, Barbot de Marny, from the lower mountain-limestone of the Gouvernement Tula which is somewhat similar; but though this shell belongs also to the *Trochidæ*, yet it is no *Margarita*, but very likely an *Oxytele*. Thus the similarity is only an apparent one, and the two shells have nothing to do with each other.

The *Trochidæ* are in general not very largely represented in the upper palæozoic periods, and most of them belong to the genera *Gibbula*, etc. Only *Troch. lepidus*, Kon., might also be a *Margarita*, but this species is distinct from the one described here by its marked spiral striation.

Sub-order: FISSOBRANCHIATA.

Tribe: SCHISMATOBRANCHIATA.

Family: *PLEUROTOMARIIDÆ.*

Genus: PLEUROTOMARIA, Defr.

This genus is one of those which are most easily recognised among all the genera of Gasteropoda; but not only this, it is also most rich in forms, and therefore a more detailed study of the shells belonging to it might lead to similar discoveries in connection with the developmental history of the organisms, as has been the case, for instance, with the Cephalopoda; thus it would be one of the most welcome undertakings to publish a monographical account of all species of *Pleurotomaria*. It is not possible for me to go at any length into the subject, all that I shall be able to do is to point out certain peculiarities which make it probable that among the *Pleurotomariæ* similar developmental series may be indicated, as have been observed to exist among the *Ammonites;* and a careful comparison of these fossils might, moreover, lead to a firmly based homotaxis of the beds in which they occur, as has been established in mesozoic strata by the study of the developmental series of the *Ammonites.*

It has been advocated by several authors that the genus *Pleurotomaria* ought to be divided into several separate genera, and Deslongchamps has proposed to introduce some names for separate divisions of *Pleurotomariæ*. As far as the knowledge of these shells goes at present, it seems highly probable that such a division into several genera will be useful and practicable, but as shells with the mouth well preserved are rather rare, it is not easy to fix the characters by which the several genera should be distinguished.

Those genera, a revision of which has been given by Stoliczka, are in most cases readily distinguished; but even with *Forskalia* it remains doubtful whether the species quoted by Stoliczka from palæozoic formations, and which are closely connected with more broadly conical and less trochiform species, can be united with the recent genus, or should better still remain with the host of other species which could not yet be distributed into separate genera on account of the absence of an exact knowledge of the shape of the mouth.

The lot of species, however, which thus remains in the genus *Pleurotomaria* is so large that it becomes absolutely unavoidable to distinguish some groups of forms within the genus. Whether it will be better to introduce a number of subgeneric names for such divisions, or whether the grouping should better be done without giving such names, is a matter of taste, and the question will be solved by different authors in different ways.

The materials in the Salt-range collection are not very extensive, and thus

I shall not venture to introduce new names. It will be sufficient to retain the divisions made by former writers, and to introduce an occasional new one. The authors who have treated more in detail the grouping of the species of *Pleurotomaria* occurring in palæozoic strata are chiefly Sandberger and De Koninck. The former distinguishes among the devonian species the following groups :—

1. *Graciles*—Sinistral shells with slender whorls, and simple narrow transverse ribs, rarely cancellated.
2. *Costatæ*—The whorls are provided with thick transverse ribs or folds.
3. *Euomphalinæ*—Shells with a large and open umbilicus, slender whorls, and simple striæ of growth.
4. *Simplices*—Shells without or with a very small umbilicus, without well marked spiral striation. with inflated whorls and simple striæ of growth.
5. *Multicarinatæ*—Whorls with numerous well developed spiral ribs or keels.
6. *Solariiformes*—Whorls with a concave basis, very depressed spire; in general form resembling *Solarium*.
7. *Nodulosæ*—Sinistral, upper part of the whorls with little nodules.
8. *Turritæ*—Spire elevated with few strong spiral ribs and simple striæ of growth.

The last division cannot be retained in the sense in which it is proposed by Sandberger, as thus it would include also all the species of *Murchisonia*. If we wish to accept the division of the *Turritæ* this can include only the *Pleur. quadrilineata*, Sandb. (*Pleur. defrancei*, d'Arch. et deVern.) and its relations; then in the sense thus defined the *Turritæ* will form a very well characterised section of the genus *Pleurotomaria*.

Mons. de Koninck is less explicit in the definition of divisions within the genus *Pleurotomaria*. He distinguishes only: "*Pleurotomariæ ornatæ falcatæ*" and "*Pleurotomariæ globatæ*."

Among the species of *Pleurotomaria* occurring in the palæozoic deposits of the Salt-range three different types can be distinguished. One of the species can be attributed to the division of the *Multicarinatæ* of Sandberger, two others to the *Turritæ*, and one remaining species belongs to a division of forms which is not represented in the devonian period, and which therefore finds no place in Sandberger's classification. This species belongs to a section of the genus which has its chief development in secondary strata, and the type of which seems to be most characteristically developed in *Pleur. conoidea*, Desh., from the inferior-oolite. I am therefore inclined to give to this division of *Pleurotomariæ* the designation of the "*Conoideæ*." This section of the genus will be characterised by a more or less elevated conoidal form, a somewhat triangular section of the whorls, and a narrow slit-band situated near the outer and lower angle of the volution.

We have in the palæozoic strata of the Salt-range the different sections of the genus *Pleurotomaria* represented by the following species :—

I. MULTICARINATÆ.

1. *Pleur. punjabica*, Waagen, n. sp.

II. Turritæ.

2. *Pleur. sequens*, Waagen, n. sp.
3. „ *durga*, Waagen, n. sp.

III. Conoideæ.

4. *Pleur. kattaensis*, Waagen, n. sp.

If we consider the single species several very interesting conclusions may be drawn. *Pleur. punjabica* agrees very much in its general form with *Pleur. ouralica*, Vern., and seems to be only distinct from it by two sharp keels which accompany the slit-band on both sides; on the other hand, it is also very near in form to *Pleur. nitida*, Barbot de Marny, which differs from our species only by an obtuse ridge surrounding the base of the shell and giving a somewhat angular section to the whorls. *Pleur. ouralica* was found in the lower carboniferous limestone of the Ural, whilst *Pleur. nitida* is a permian species. There cannot, I think, be any doubt that these species, together with the Indian fossil, form a developmental series which may be designated as "Group of *Pleur. ouralica*, Vern." The series seems to continue still further up in the sequence of formations, as there are some triassic species, like *Pleur. baucis*, Dittm., and *Pleur. daphne*, Dittm., from the Hallstadt beds, bearing a certain resemblance to the palæozoic shells.

Very similar facts may be observed in connection with *Pleur. sequens*, W. This species belongs to a group of forms which begins already in the devonian period with *Pleur. quadrilineata*, Sandb. In the mountain-limestone a species seems to occur which is very similar to the devonian shell, but can be distinguished according to Koninck's figure (in the text the species has not been mentioned) by a more depressed spire and an upper keel, which is nearer to the suture. These characters are even more developed in the Indian *Pleur. sequens*. Thus it seems highly probable that here also a developmental series of forms exists.

Again, another fact similar to those discussed above is the similarity of *Pleur. kattaensis* to *Pleur. conica*, Phill., of the mountain-limestone of Bolland. Both species agree very closely with each other, and there is a great probability of the former species having taken its origin from the latter.

Thus the origin of three of the species of *Pleurotomaria* occurring in the palæozoic deposits of the Salt-range can be traced with more or less probability either to species of the mountain-limestone or even down to devonian strata. Only with one species this origin remains uncertain.

I.—MULTICARINATÆ.

a. Group of PLEUROTOMARIA OURALICA, Vern.

1. Pleurotomaria punjabica, Waagen, n. sp. Pl. XI, figs. 3, 4.

The general form of the shell is more or less globose, the spire depressed, consisting of few rather inflated whorls. The whorls are angular in the middle, where

the very narrow band is situated, and flattened both above and below the angular part. The last whorl is the largest of all, and tolerably strongly inflated; the base of it is well rounded, uniting with the lateral part of the whorl in a very obtuse barely perceptible edge. In the middle of the base there is a small and deep umbilicus in consequence of the columella not being solid.

The aperture is large and roundish, very slightly effuse in front, the inner lip not thickened, the outer one with a deep slit in the middle, the form of which cannot be well observed in any of the specimens. In the one figured the slit seems to be very broad, but this is probably in consequence of the part of the shell limiting the slit on its upper side being partly broken away. From the sculpture of the shell it seems likely that the slit was narrow, with parallel margins.

The ornamentation of the shell is only very rarely well preserved in the specimens I have got for description, and thus in most cases the shell seems to be smooth, with the exception of two sharp ridges which limit the narrow slit-band on both sides. When, however, the entire surface of the shell is well preserved, numerous low spiral ridges cover the whole shell, and are crossed by very much finer barely perceptible striæ of growth.

The species never attains any considerable size, and specimens of a little above ten millimeters in length are the largest that have been observed. The dimensions of two specimens, No. I from Chidru, No. II from Katwáhi, are as follows:—

	I.	II.
Total length of shell	10·5 mm.	8·5 mm.
Greatest breadth of shell	11·5 „	9 „
Height of the last volution at the aperture	7 „	6 „
Breadth of the aperture	7 „	5·5 „
Apical angle	97°	90°

The apical angle varies from 71° to 107°.

Locality and geological position.—This is one of the species of Gasteropoda which occurs in tolerable numbers in the palæozoic deposits of the Salt-range, though it is by far more scarce than, for instance, *Macrocheilus avellanoides*, Kon. There are altogether sixteen specimens of this species preserved in the Salt-range collection, ranging from the lower through the middle to the upper division of the Productus-limestone, though in the last of the three the species is most common.

One specimen of this species was collected by myself in the Nilawán, in the lower division of the Productus-limestone; one specimen was found also by me in the upper beds of the middle division of the Productus-limestone, west of Khura. In the lower and middle beds of the upper division of the Productus-limestone this species was collected by myself west of Khura (one specimen), at the village of Khura (one specimen), at Katwáhi (two specimens), at Kufri (five specimens), and by Mr. Wynne at Khund Ghât (two specimens). In the very top beds of the upper division of the Productus-limestone, I have found the species at Chidru (three specimens), and at Virgal (one specimen).

Remarks.—This species so very closely resembles *Pleur. ouralica*, Vern., that it seems necessary to indicate by what characters the two species differ. The Indian species has a somewhat more depressed spire, the whorls are more flattened on their upper part, and show a very obtuse edge at the place where the basal and the lateral parts of the whorls unite. The chief character, however, by which it seems possible to separate the two species lies in the slit-band, which is accompanied on both sides in our species by a sharp keel, whilst these keels are absent in *Pleur. ouralica*. This character is not owing to the manner of preservation of the Russian shell, for if their keels had been obliterated by weathering or rubbing the striation on the other parts of the shell must also have disappeared, as in *Pleur. punjabica* the striation of the shell has vanished in most cases, but the two keels near the slit-band are always well preserved.

This peculiarity of preservation in *Pleur. punjabica* is worthy of notice. Nearly all the specimens I have for description show a perfectly smooth shell with the exception of the keels near the slit-band, and only one specimen from Chidru has the surface of the shell so well preserved that the spiral striation on the other parts can be easily observed.

Thus *Pleur. punjabica* seems to be a well characterised species and easily distinguishable from *Pleur. ouralica*. Another species to be compared is *Pleur. nitida*, Barbot de Marny. This species has its spire a little more elevated than the two species already mentioned, but in its general form it resembles both more or less. It is distinct from *Pleur. ouralica* as well as from the Indian form by its more prominent slit-band, and by the strongly developed obtuse edge which surrounds the base of the shell. The surface sculpture of the shell of *Pleur. nitida* is, however, not known, as the species has been observed up to the present only in the form of casts.

It is of interest to draw attention to the geological position of the species here mentioned. *Pleur. ouralica* is geologically the oldest of the three. It has been found at Kosatchi-Datchi in the mountain-limestone, together with *Productus giganteus*, and belongs thus to the fauna of the lower division of the mountain-limestone of Russia. *Pleur. punjabica* is, beyond doubt, younger in the geological sequence, and very likely *Pleur. nitida* must be considered as the youngest of the three; thus it seems highly probable that *Pleur. ouralica* is the ancestor of the Indian species, while it is less certain whether *Pleur. nitida* has taken its origin from *Pleur. punjabica*, as the surface sculpture of the former species is not known up to the present.

II.—TURRITÆ.

(*a*). Group of PLEUR. QUADRILINEATA, Sandb.

2. Pleurotomaria sequens, Waagen, n. sp. Pl. IX, figs. 4, 5; Pl. XI, fig. 7.

Next to the species just described this one is the most common of *Pleurotomariæ* in the palæozoic deposits of the Salt-range.

The general form of the shell is elevated conical, the spire is tolerably high, consisting of four or five not very inflated rather slowly increasing whorls. The latter are ornamented by prominent spiral costæ, two of which are situated about in the middle of the whorl, and accompany the slit-band on both sides, one is not far from the suture, and another separates the base of the shell from the lateral part of the whorl. All four ridges cannot be seen in every specimen on the upper volutions, as the lower ridge often gets concealed by the suture. In some specimens, however, the suture is inserted just below the lower ridge. The sutures between the single whorls are sharply cut in and very distinct. The base of the shell is rounded, not flat, and in young specimens covered with a very distinct spiral striation; there are about eight of these spiral ridges observable. In old specimens, however, this spiral striation of the base becomes more and more indistinct, and at last disappears entirely. The columella is not solid, but the umbilicus thus formed is very small, and in some specimens entirely concealed. The whole surface of the shell is covered in well preserved specimens by fine striæ of growth, which show a tolerably deep insinuation on the slit-band. The aperture is nearly circular, not effuse in front. The inner lip is not thickened, but sometimes very little expanded so as to cover up the very small umbilicus; the outer lip has an insinuation in the middle, the extent of which cannot be observed in any of the specimens.

The measurements of two specimens are as follows:—

	I.	II.
	mm.	mm.
Total length of shell	11	6
Greatest breadth of shell	10	6
Height of the last volution at the aperture	6	3
Breadth of the aperture	5	3
Apical angle	66°	70°

Very few specimens attain a size exceeding that of specimen No. I, and the species thus appears to be generally of rather small size.

Locality and geological position.—The species is not very rare in the palæozoic deposits of the Salt-range, but seems to be restricted there to the upper division of the Productus-limestone, as no specimens have been detected up to the present either in the middle or in the lower division of the same formation. The species was found in the upper division of the Productus-limestone by myself at the village

of Khura (two specimens), and in another section west of that village (one specimen), at Kufri (four specimens), and by Mr. Wynne at Khund Ghât (one specimen). In the topmost beds of the upper division of the Productus-limestone I have collected the species at Virgal (one specimen) and at Chidru (two specimens).

Remarks.—There is but one series of forms to which our species seems to be more closely related: this is *Pl. quadrilineata*, Sand., and the species more or less nearly allied to it. Though a number of species belonging also to the "*Turritæ*" occur in North America in the coal-measures, yet there seems to be no shell among them to which our species could be more closely compared. Also the similarity to *Pl. quadrilineata* is not such that a specific identity could be advocated by anybody. In the first place, the size of *Pl. sequens* is much less considerable than that generally attained by *Pl. quadrilineata*, then the spire is much more depressed, and in the young shell a spiral striation is observable on the base of the Indian species, which seems to be always absent in the devonian shell. It is very unfortunate that nothing definite is known about a gasteropod figured by De Koninck, but not described; Koninck identified the shell with *Pl. defrancei*, D'Arch. et De Vern., which species is identical with *Pl. quadrilineata*, Sandb.; but nobody knows whether De Koninck's specimen came from the carboniferous limestone of Visé or from devonian strata. As appears from the figure, the form drawn by Koninck seems to be more closely related to the Indian species than that figured by Sandberger. If Koninck's specimen was a carboniferous shell, it would certainly be worthy of a new designation, and would furnish a very remarkable link between the devonian *Pl. quadrilineata* and the upper palæozoic Indian species.

Bigsby, in his Thesaurus Devonicus, says of *Pl. defrancei*: "also carboniferous at Visé," but does not mention the species again in his Thesaurus Carboniferous.

(*b*). Group unknown.

3. Pleurotomaria durga, Waagen, n. sp. Pl. X, fig. 1.

The general form of the shell is depressed conical. Spire short, consisting of about four whorls. The latter are flattened above and angular on their outer side. There are three principal spiral ridges observable on the whorls, between which five or six very fine thread-like ribs are intercalated. Beginning from the suture, two ridges of the finer sort appear, then comes one strong and high one, then again two very fine which are only visible on well preserved specimens. After these, two high angular ridges are observable, situated on the angle between the base and the lateral part of the whorl. At the base again one spiral ridge of medium size occurs near the outer margin, but the remaining part of the base of the shell is smooth, without spiral ridges. The slit-band is situated between the two high ridges next to the base of the shell. Besides these spiral ridges there are on the whorls very fine

striæ of growth, which are, however, not very closely arranged, and cause no granulation in crossing the spiral ridges. They are slightly directed backwards from the suture to the slit-band, show on this band a rather shallow insinuation, and from there reach the umbilicus in a somewhat falciform curve. The base of the shell is somewhat flattened, smooth, with a moderately wide umbilicus in the middle.

The aperture is ovate, not effuse in front, angular on its outer side. The inner lip is not thickened or expanded, the outer one bears on its lower angle an insinuation, which seems to be rather broad and shallow.

The dimensions of two specimens No. I from Amb, No. II from Khura, are as follows:—

	I.	II.
	mm.	mm.
Total length of shell	7	8
Greatest breadth of shell	8·5	10
Height of the last volution at the aperture	4	5
Breadth of the aperture	5·5	6
Diameter of the umbilicus	1	2
Apical angle	92°	100°

The specimen No. II is the largest of this species that has been observed up to the present.

Locality and geological position.—This species is rather rare in the palæozoic deposits of the Salt-range. It has been observed up to the present only in the upper division of the Productus-limestone, and occurs there chiefly in the topmost beds. The species was collected by myself at Amb (three specimens) and at the village of Khura (two specimens).

Remarks.—Though there are several species to which the form here under consideration might be compared, yet the resemblance is not very close, and it is very improbable that in reality any nearer relation between these species exists. Among European shells there is only *Murchisonia sulcata*, M'Coy, to which *Pl. durga*, W., bears a superficial resemblance. In M'Coy's species the spire is much more elevated, and the spiral keels, of which I count six on M'Coy's drawing, are all equally strong, and the slit-band seems to be very broad, all characters by which it differs essentially from *Pleur. durga*.

Of American species chiefly *Pleur. brazoensis*, Schum., and *Pleur. subconstricta*, M. and W., might be compared. Both are species of the upper coal-measures, and chiefly the latter exhibits characters somewhat resembling those of *Pleur. durga*, but it can easily be distinguished by a row of small nodules on the upper margin of the volutions near the suture, and by the absence of an umbilicus.

Pleur. durga must thus be considered as an isolated form, the true relations of which cannot be ascertained for the present.

III. CONOIDEÆ.

(*a*). Group of PLEUROTOMARIA CONICA, Phill.

4. Pleurotomaria kattaensis, Waagen, n. sp. Pl. XI, figs. 5, 6,

This is a very rare species, of which no entire specimen has been found up to the present, but the materials at hand are sufficient to describe the species with all desirable accuracy.

The general form of the shell is elevated conical, very little broader than high. The spire consists of five or six whorls, of which the upper three are somewhat differently shaped in comparison to the rest. The first three volutions are perfectly flat, somewhat triangular in their section, and rather acutely angular at the periphery, where the very narrow slit-band is situated. Later on the volutions get a flattened periphery, as below the slit-band a flat vertical zone is developed, which appears above the suture and gives to the shell a scalate appearance. This zone does not get much broader as the shell increases in size.

The surface of the whorls is ornamented with a closely arranged very fine, barely perceptible, spiral striation, crossed by much stronger transverse folds, which lie in a retrograde direction with an elegant curve from the suture to the slit-band. The slit-band is excavated and rather narrow; it is accompanied on both sides by a narrow ridge, sharp, but not prominent. On the flat zone below the slit-band sometimes the spiral striation and sometimes the transverse folds predominate.

The base of the shell is flattened and smooth without spiral striation. It bears in the middle a small but deep umbilicus.

The columella is excavated, the aperture more or less trapezoidal, not effuse in front. The inner lip is straight, not thickened or expanded, the outer lip angular, with an apparently not very deep emargination near the lower angle.

The dimensions of two somewhat fragmentary specimens from Katta are approximately as follows:—

	I.	II.
Total length of shell	12 mm.	7·5 mm.
Greatest breadth of shell	12 „	8 „
Height of the last volution near the aperture	5 „	3 „
Breadth of the aperture	6 „	4·5 „
Diameter of the umbilicus	2 „	1·5 „
Apical angle	70°	73°

The largest specimen of this species, but very badly preserved, was collected by me at Nursingphoár, and measures about 20 mm. in height.

Locality and geological position.—This is a rather rare species in the palæozoic deposits of the Salt-range. Altogether three specimens of it are known to me; two of these were collected by me in a yellow compact limestone (bed No. 12 of the section in my note-book) belonging to the lower region of the middle division of the Productus-limestone, north of the village of Katta, and another was found

by me in a coaly calcareous sandstone composing the lowest fossiliferous bed of the middle division of the Productus-limestone at Nursingphoár. Thus the species seems to be restricted to the lower layers of the Productus-limestone, and to be altogether absent from the upper division of the same formation.

Remarks.—This species is of a group of forms which is not very largely developed in the carboniferous period; nevertheless in Europe as well as in America, there are some species which bear a certain resemblance to the Indian shell.

In Europe it is chiefly *Pleur. conica*, Phill., which is very closely related to *Pleur. kattaensis;* and the similarity of the two shells is indeed so close that I am inclined to believe that the fossil from Bolland is an ancestor of the Indian shell. The whole difference between *Pleur. conica*, Phill., and *Pleur. kattaensis* consists, as it seems, in a less angular section of the whorls and a more closely arranged oblique transverse plication in the Yorkshire species.

Other species which are also rather closely allied to *Pleur. conica* and to our species are *Pleur. turbiniformis*, M. and W., and *Pleur. subscalaris*, M. and W., both from the lower coal-measures of Illinois. *Pleur. turbiniformis* seems to be nearly identical in form with the very young stages of growth of *Pleur. kattaensis*, but already with the third volution of species the similarity decreases, and the full-grown shells can easily be distinguished by the flat vertical zone below the slit-band on the last volutions in *Pleur. kattaensis*. In *Pleur. subscalaris*, M. and W., again it is only the young shell which can be compared to the Indian fossil, full-grown specimens being entirely different. *Pleur. kattaensis* seems to hold just the middle between the two American species. I shall not venture to decide whether any of the American shells have derived their origin from *Pleur. conica*, Phill., or whether *Pleur. kattaensis* stands in any developmental connection to *Pleur. turbiniformis* or *subscalaris;* but this seems probable, that *Pleur. conica*, Phill, and *Pleur. kattaensis*, W., stand in some sort of developmental connection to each other.

Genus: MURCHISONIA, Arch. and Vern.

Though this genus seems not to differ very widely from *Pleurotomaria*, yet on a closer examination a distinction is not only easy, but seems even absolutely necessary. In specimens in which the mouth of the shell is not very well preserved the genus can be recognised by the elevated spire and the great number of whorls, a form of the shell which is not usual in the genus *Pleurotomaria*. If the mouth of the shell, however, is well preserved, the shape of that part is so very characteristic, that it seems barely possible to unite the shells of *Murchisonia* with the common *Pleurotomaria*. Whilst in *Pleurotomaria* the mouth is anteriorly generally perfectly rounded and only in very rare cases slightly effuse, in *Murchisonia* it is generally strongly effuse and in many cases even canaliculate, like in *Pyramidella* or *Cerithium*.

Easy as it thus may be to recognise the genus, it is difficult in many cases to distinguish the several species.

The genus is represented in the palæozoic deposits of the Salt-range by a single species, belonging to a group of forms largely represented in palæozoic strata, but in which the distinction of the single species seems to be extremely difficult; this is the group of *Murch. angulata*, Phill., which seems to commence already in silurian beds and continues in manifold variations up into triassic strata.

The group seems to commence in upper silurian strata with *M. perangulata*, Hall, which species has already most of the characters of the group well developed. Whether in the lower silurian period *M. pagoda*, Salt., which has been found in these beds in the Himalaya, and which by the characteristic high elevated angular keel bearing the slit-band and by other characters recalls to a certain extent the form *M. angulata*, has to be considered as the first representant of the whole group, is a question which cannot be solved here. In devonian strata we have *M. anglica*, Orb. (*M. angulata*, Phill., 1841). This species already very nearly agrees with *M. angulata*, but seems to differ from it by a doubly carinated keel and a slit-band situated between the two carinæ.

The true *M. angulata*, Phill., occurs in the mountain-limestone. It is very much to be regretted that there exists no good figure of this species, a want which would account for the species being so very often mistaken. Though the figure given by Phillips in his Geology of Yorkshire is not executed very carefully, it seems to be very characteristic, and the species might be well recognised by it; but only M'Coy (Palæozoic fossils, p. 531) seems to have recognized the typical species, and given a diagnosis of it which perfectly agrees with Phillips's drawing. The specimen figured by Portlock might also belong to the species, but the apical angle seems somewhat larger than that indicated in the figure given by Phillips, and the principal keel seems to be lower down near the base of the whorls; so that it is probably better to exclude Portlock's specimen from the true *M. angulata*. Similarly, all the figures given by M. de Koninck must beyond doubt be excluded from Phillips's species. From all this it seems certain that *M. angulata* is a species with a not very strongly elevated spire, sharply angulated whorls bearing in the middle a mostly simple prominent keel, and a second keel surrounding the base of the whorl. This second keel is not quite covered up by the following whorl, but appears immediately above the suture as a thread-like spiral ridge. Other carboniferous species, like *M. verneuillana*, Kon., *M.* (*Vern.*) *kendalensis*, M'Coy, etc., which with great probability belong also to the group of *M. angulata*, must be left out of consideration here, as the true relations of those species can only be ascertained in a monographical review of the whole group.

In permian beds, the group of *M. angulata* is represented by two species, *M. subangulata*, Vern., and *M. biarmica*, Kut. Both species are not very difficult to distinguish from *M. angulata*, the first by the absence of the second prominent

keel surrounding the base of the shell, the second by a spiral striation which covers the surface of the shell above and below the median keel. Though Golowkinsky has advocated recently the identification of the two species, Geinitz has already, in his Dyas, rightly pointed out their distinctive characters.

Very nearly related to *M. biarmica*, Kut., there seems to be *M. tramontana*, Stache, from the *Bellerophon*-limestone of the Alps. This species has the most elevated spire of all those hitherto mentioned, and in it not only the second, but also the principal median keel begins to disappear. A spiral striation is present, like in *M. biarmica*.

After this a long break in the series occurs. One or the other of the small Gasteropoda figured by Benecke from the Buntsandstein of the Alps, and possibly also *M. tricarinata*, Klippst., from Cassian and Hallstadt beds, might yet belong to the series, but this cannot be positively asserted.

Also in America there occur members of the same group of forms like *M. marcouiana*, Gein., which very likely also took their origin from *M. perangulata*, Hall; but the species are all different from those occurring in the eastern hemisphere, and there is no doubt that the American shells were vicarious species, replacing the eastern forms at similar geological periods in the western seas, separated more or less from the east by great distance and by land barriers in middle and upper palæozoic times.

In the palæozoic deposits of the Salt-range there occurs a species of *Murchisonia*, which, though not agreeing specifically with any of the species hitherto described, fits well into the series of forms more or less allied to *M. angulata*, as they occur in the eastern hemisphere. I shall call this Indian species *M. conjungens*, W. This species holds exactly the middle between *M. angulata* and *M. biarmica*, and must thus be considered as a truly transitional form.

If we now recapitulate what has been said about the development in time of the group of *M. angulata*, we come to the following results. We have :—

In the Bellerophon-limestone	*M. tramontana*, Stache.
„ permian beds	*M. biarmica*, Kut., *M. sub-angulata*, Vern.
„ Salt-range	*M. conjungens*, W.
„ mountain-limestone	*M. angulata*, Phill.
„ devonian beds	*M. anglica*, Orb.
„ upper silurian deposits	*M. perangulata*, Hall.
„ lower silurian strata	*M. pagoda*, Salt.

There is no doubt that there exists a large break between *M. pagoda* and *M. perangulata*, and it might even be questioned if the former species is really in developmental connection with the latter. It will, therefore, not be advisable to give the name of *M. pagoda* to the whole developmental series, but to start from *M. perangulata* as the root-species.

There is a marked tendency in this developmental series to elevate more and more the spire, to get more and more numerous whorls, and to efface gradually the two

prominent keels with which the whorls are provided. The lower of these, surrounding the base of the shell, is lost first; and at last the principal keel also, in the middle of the whorls, is only developed on the last whorls in *M. tramontana*, whilst the upper volutions are simply convex.

(*a*).—Group of MURCHISONIA PERANGULATA, Hall.

1. Murchisonia conjungens, Waagen, n. sp. Plate XII, figs. 1, 2, 3.

The general form of the shell is very elongately turreted, with a narrow base and a pointed apex. The very much elevated spire seems to have consisted of ten to twelve volutions, but this cannot be exactly ascertained, as no complete specimen of the species has been found.

The whorls are convex and somewhat squarish in their section. The suture between the whorls is deeply impressed, and marked by a slightly prominent thread-like line, caused by a keel which surrounds the base of the whorls, but which is nearly quite concealed below the following whorl. The external part of the whorls is strongly angular, with a high prominent keel a little below their middle. Above and below this keel, there are flat or even concave sloping zones of the shell, of which the upper one, in well preserved specimens, bears three revolving lines between the keel and the suture, whilst the lower one shows only one such line between the keel and a second less prominent ridge which surrounds the base of the shell. The base of the shell is flat or even concave, without umbilicus, a slight impression in its place, however, being present. The columella is compact and slightly projecting. The aperture is somewhat squarish, angular, and strongly effuse in front. The inner lip is thin, very slightly expanded and reflexed, the outer one bears a very broad but not very deep angular emargination, corresponding to the slit-band which runs along on the top of the principal keel.

No specimen in the collection is sufficiently well preserved to observe the direction of the striæ of growth.

The dimensions of two of the specimens, No. I, from Khund Ghât, No. II, from Chidru, as far as they can be observed, are as follows:—

	I.	II.
Total length of shell, about	56 mm.	45 mm.
Length of the preserved part	40 „	15 „
Greatest breadth of shell	12 „	9 „
Height of the last volution at the aperture	8 „	6 „
Breadth of the aperture	3 „	6 „
Apical angle	14°	15°

Locality and geological position.—The species here described is not common in the palæozoic deposits of the Salt-range, and seems to occur there exclusively in the upper division of the Productus-limestone. It was collected by myself in the very

top beds of the Productus-limestone at Chidru (one specimen) and at Virgal (one specimen). In the middle beds of the upper division of the Productus-limestone it was found by myself at Kufri (one specimen) and by M. Wynne at Khund Ghât (two specimens).

Remarks.—The species which has just been described belongs to a group of forms very extensively developed in palæozoic times, and which chiefly in upper palæozoic strata has many representants. Among the shells hitherto described there are especially two species which very closely resemble our form; these are *M. biarmica*, Kutorga, and *M. angulata*, Phill.

The points of similarity between *M. biarmica* and our species consist, besides the general form of the shell which is common to all the species of the group, in a spiral striation on the whorls, as well above as below the angular keel, which is absent in all the other shells of the group. On the other hand, *M. conjungens* differs from *M. biarmica* by the presence of a rather high spiral ridge surrounding the base of the shell.

With *M. angulata*, Phill., our species agrees in having a rather prominent ridge surrounding the base of the shell, and which is still visible on the upper whorls immediately above the suture as a thin, thread-like keel; it differs, on the other hand, from Phillips' species by a spiral striation, which is present on the whorls above and below the principal angular keel.

Thus *M. conjungens* in all its characters forms a truly transitional species between *M. angulata*, Phill., and *M. biarmica*, Kut.

Very nearly allied is also *M. subangulata*, Vern., but this species has no spiral striation above the principal angular keel, and the spiral ridge which surrounds the base of the shell in *M. conjungens* is absent in Verneuil's species.

M. conjungens is not always so well preserved that all the characters can be seen in every specimen; the spiral striation on which the distinction from *M. angulata* is based, is most liable to obliteration by weathering. But as that striation is still observable in specimens where the striæ of growth cannot be observed any longer, whilst *M. angulata* seems to show the striæ of growth very clearly without exhibiting a spiral striation, this character cannot depend upon the state of preservation alone, but must be one connected with the characters of the shell in general.

Tribe: DICRANOBRANCHIATA.

Family: *BELLEROPHONTIDÆ.*

Nothing seems to be more difficult than to classify fossil shells of extinct families of which no living representant any longer exists. What difficulties are to be encountered in such an undertaking appear at once most clearly from the difference of opinion existing among most distinguished palæontologists in treating of the same shells or in attempting to assign a place to them in the system.

In no instance is this more clearly exhibited than in the case of the genus *Bellerophon*, which has been successively assigned to the *Cephalopoda*, to the *Prosobranchiata* and the *Opisthobranchiata* of the *Gasteropoda*, and to the *Heteropoda* and the systematic position of which seems even now by no means certain.

The family consists exclusively of fossil forms, and thus the animal which once inhabited the shells belonging to the family is absolutely unknown.

The shells are characterised by their symmetrical configuration, being enrolled in one plane like the shells of *Nautilidæ*. The mouth of the shell is broadly oval or sagittate, generally more or less enlarged, and provided on the outer lip with a slit, which corresponds in most cases with a slit-band on the former volutions. Inner lip generally more or less callous, sometimes provided with columellar folds. Shell comparatively thick and heavy.

The supposition of these shells being *Cephalopoda* was originally made by Montfort, who attributed to his genus a number of septa pierced by a siphuncle. This condition was soon proved to be erroneous, but nevertheless the opinion of the cephalopodous nature of these shells was not given up; they were then considered as monothalamous Cephalopod shells. If we look through all the shells recent and fossil, which beyond any doubt belong to the class of Cephalopods, there is absolutely no other shell to which the Bellerophons could be compared except *Argonauta*. The characters of this latter shell consist chiefly in its being very thin, its consisting of only one and a half whorls, and in an arrangement of the striæ of growth such as exists in no other Cephalopod known to me. The shell itself is made up of a hard calcareous substance, which has a vivid pearly lustre on the fracture, but is dull on the inside, and polished without. It has none of all these characters in common with the shell of *Bellerophon*. The fossil shells belonging to *Bellerophon* are in general very thick and heavy in comparison with *Argonauta*. They consist of at least three whorls, mostly of more, and the striæ of growth go regularly from the umbilicus to the convex side of the whorl, and are here interrupted by a slit-band or a simple insinuation, such as occurs in the family *Pleurotomaridæ*. Only the forms without a slit-band, like *Bell. bilobatus*, Sow., bear in their mouth a certain resemblance to the mouth of *Nautilus*. But otherwise they cannot be compared with *Nautilus* in any way. The most striking character of *Nautilus* is just the existence of air-chambers in the shell, which are entirely absent in *Bellerophon*.

The structure of the *Bellerophon* shell cannot be made out distinctly in any of the specimens at my disposal, as it has been transformed in almost every case into calc-spar, but it can be observed that it was shining inside and dull without. Only one specimen, the shell of which has been silicified, shows very clearly that the whole thickness of the shell was made up of very thin calcareous lamellæ, which, when fresh, must have possessed a vivid pearly lustre. Otherwise the specimen is too ill preserved to observe if there was an outer shell layer of a different structure present. Thus it would be at least hazardous to unite the Bellerophons with the

Cephalopods, as we know of no monothalamous shell among Cephalopods which would be secreted by the mantle, as was beyond doubt the case with Bellerophon. This is shown already by the strong callosity which covers in many cases the columellar lip of the mouth of the shell.

The idea of these shells being *Heteropoda* originated with Deshayes, and has since then most generally been accepted in science. The analogies of some forms of shells considered to belong to the *Bellerophontidæ* to the shells of some living *Heteropoda* are indeed sometimes striking. Thus if we take for a comparison that group of forms which has been subsumed by Meek under the generic designation of *Tropidodiscus*, or if we take Conrad's genus *Cyrtolites*, the resemblance between these shells and the shell of *Atlanta peronii*, Les., or *Oxygyrus* (*Helicophlegma*) *keraudrenii*, Les.,[1] is very close externally, but the two living species are glassy, thin or even cartilaginous shells, whilst the fossil ones are always thick; and whilst the animals inhabiting the shells above-mentioned are exclusively pelagic creatures, the shells of the fossil genera are always found in more or less littoral deposits. If, however, there are already some points of discrepancy in those fossil shells which most nearly agree in their general form with the shells of living *Heteropoda*, these discrepancies increase to an enormous extent if we compare other forms of the *Bellerophontidæ*, chiefly the typical forms of *Bellerophon*. These possess thick heavy shells, with a thick callosity on the umbilicus and the inner or columellar lip of the mouth, and with a distinct slit-band on all the whorls. All these characters are absolutely wanting in the shells of *Atlanta* or *Oxygyrus*.

The systematic position which has been attributed to the *Bellerophontidæ* by Blainville is with the *Opistobranchiata* of the Gasteropods. There are indeed some shells among that division of Gasteropods which are more or less symmetrical, for instance, *Haminea*, Leach, or *Atys*, Montfort; but the *Bellerophontidæ* not only never show the punctured surface which is generally exhibited by the shells of the *Opisthobranchiata*, but, on the other hand, in the latter order of Gasteropods no case is known of the shell bearing a slit-band such as generally occurs in the *Bellerophontidæ*, and thus the analogies between the latter family and the *Opisthobranchiata* seem to be rather small.

There remains then only the *Prosobranchiata*, with which a closer comparison must yet be attempted. If we wish to do this, we must turn, in the first place, to those forms among the shells of this order which bear, like *Bellerophon*, a slit-band on their whorls, and we are thus led most naturally to the sub-order "*Fissobranchiata*," in which nearly all the genera included bear either a slit-band or a row of perforations, or at least an emargination, on the mouths of their shells.

[1] Only the embryonal shell of *Oxygyrus keraudreni* up to 0·3mm. diameter has a striking similarity to *Bell. urii*, but the full grown individuals are absolutely different, the shell is only cartilaginous, and not in the slightest degree similar to the mentioned fossil species. Thus also the similarity of the embryonal shell can only be an apparent one.

Already in 1843 Mons. de Koninck had drawn attention to a certain analogy which exists between the *Bellerophontes* and *Emarginula*, placing the former in the system somewhere in the vicinity of the latter genus. This example has been followed by Pictet and Geinitz; and in 1866, in a note in the Proceedings of the Chicago Academy of Sciences, Meek very strongly advocates the position of the *Bellerophontes* somewhere near *Pleurotomaria* and *Haliotis*.

The points of similarity between the shells of *Pleurotomaria* and those of the *Bellerophontidæ* are indeed manifold. The species of the genus *Bellerophon* agree in every respect with *Pleurotomaria*, except in their being symmetrical. The form of the *Pleurotomariæ* varies in being sometimes turreted, sometimes very nearly coiled in one plane, as in *Porcellia*, which genus has already by Stoliczka been separated from the *Bellerophontidæ*, with which it had been united by many former writers. The mouth of the shell is always provided on its outer lip with a more or less strongly developed incision, which is in most cases a narrow and deep slit, sometimes a broad insinuation, as in *Platyschisma*, sometimes a short angular emargination, as in *Forskalia*. Where a deep slit is present, it leaves on the former volutions distinct traces, though the slit itself be filled up with shelly matter, and thus the slit-band is formed. This slit-band consists in some rare cases of a row of oval openings, as in *Polytremaria*. The inner lip of the mouth of the shell in the *Pleurotomariæ* is mostly simple, but there are also cases in which a thick callosity on this lip is developed, as in *Ptychomphalus*.

All these variations in form and structure are also represented by single groups of forms which have been detected successively among the *Bellerophontidæ*. There are symmetrical and non-symmetrical forms, as has been lately described by Stache, though the unsymmetrical forms seem also to be coiled in one plane. The slit on the aperture is deep and angular in the true *Bellerophontes;* it is a broad insinuation in a certain group of forms of which several species occur in the Salt-range; it is a shallow angular emargination in another form, which I shall have to describe later on. The slit-band is well developed in *Bellerophon* proper, it is absent in other groups, and it consists of a row of oval openings in the genus *Tremanotus* of Hall, which is otherwise not distinguishable from *Bellerophon*. There are at last forms with a strong callosity on the inner lip, whilst in others this callosity is absent.

But the number of characters by which the *Bellerophontes* approach more or less the *Prosobranchiata* is not yet at an end. I shall have to describe forms in which several columellar folds are developed, a character which only occurs in the true Gasteropods, the *Prosobranchiata*, or the *Opisthobranchiata*. Besides this there have been described other forms which have the mouth so much enlarged and the enrolled part of the shell so little developed, that in general form they more or less resemble *Emarginula*, and thus furnish new analogies for the systematic position of the *Bellerophontidæ* near *Emarginula*.

If we now recapitulate what has been said about the affinities of the shells of the *Bellerophontidæ*, we find that they agree with the *Cephalopoda* in general chiefly by the symmetrical development, the thickness and pearly structure of the shell, and with the *Nautilidæ* in particular by the broad insinuation of the outer lip in certain forms; all other characters are entirely different. With the *Heteropoda* also they agree by their symmetrical shell, and with *Atlanta* in particular by the long and narrow incision of the outer lip in *Bellerophon* proper. All other characters are entirely different. With the *Fissobranchiata*, at last, the *Bellerophontidæ* agree in all characters, except the symmetrical development of their shell, which is enrolled in one plane; symmetrical shells do, however, occur in the *Fissonellidæ*, a family of the *Fissobranchiata*, though not spirally enrolled in one plane. Among the *Fissobranchiata* again the greatest affinity to the *Bellerophontidæ* is exhibited by the *Pleurotomaridæ*, which undergo in their several genera about the same changes of form that are also experienced by the former family. The preponderance of characters agreeing with those of the *Pleurotomaridæ* seems thus to be so very great, that by far the greatest probability is likely to be in the direction of a more or less close affinity of the *Bellerophontidæ* to the *Pleurotomaridæ;* and I think I cannot be very wrong if I put the former family in the sub-order *Fissobranchiata* of the *Prosobranchiata;* and as most of the forms of the *Bellerophontidæ* are symmetrical, they will have to be placed together with the family *Fissonellidæ* in the tribe "*Dicranobranchiata*," between the latter family and the *Haliotidæ* of the tribe "*Schismatobranchiata.*"

There have been described already a good many genera; but these are still far from sufficient for all the widely different forms which have been made known to exist within the family.

The principal genera described up to the present are the following:

1. Bellerophon, Montfort, 1808, Conchiliologie systématique, Vol. I, p. 51. The type species of this genus is *Bell. vasulites*, Montf., from the Mountain-limestone, with a strong callosity on the inner lip and the umbilical region, a not very deep emargination on the outer lip, and the surface of the shell simply covered by striæ of growth and a well developed raised slit-band. We shall have therefore to restrict the name *Bellerophon* to forms which bear a more or less strong callosity on the inner lip, and in which every kind of sculpture, except the more or less strongly developed striæ of growth, is absent.

2. Bucania, Hall, 1843, Palæontology of New York, Vol. I, p. 32. The characteristic given by Hall of this genus seems not quite sufficient to separate it from the true Bellerophons, and therefore this genus has by most writers been united with that of Montfort. If we consider, however, the first species described (*Buc. sulcatina*, Emmons) as the type of the genus, we shall be able to retain the genus, not for the largely umbilicated shells, but for the shells with a spiral sculpture, as the type species very clearly shows the spiral sculpture, mostly more or less reti-

culate, which is so often exhibited by *Bellerophon*. But then *Bucania*, Hall, is partly identical with *Euphemus*, M'Coy, which was created to receive the spirally striated *Bellerophontes*, only the slit-band is said to be absent in *Euphemus*.[1]

3. PHRAGMOSTOMA, Hall, 1862, Fifteenth Rep., N. Y. State, Cab. Nat. Hist., p. 60. The original description of the genus has not been accessible to me, but from the figures in the Pal. N. Y. Devon. Foss., this genus seems to contain spirally striated Bellerophonts with very much expanded mouth and an inner lip, the callosity of which is granulated and cut out where it touches the preceding whorl.

4. PATELLOSTIUM, Waagen, n. gen. I create this genus to receive the species allied to *Bell. macrostoma*, Proem., the mouth of which is very much expanded and the lips spread out *Patella*-like, the inner lip not being cut out where it touches the preceding volution. Also *Bell. megalostoma*, Eichw., will belong to this genus.

5. TROPIDODISCUS, Meek, 1866, Proceedings of the Academy of Sciences of Chicago, Vol. I, p. 9. Strongly compressed disciform shells, with a high keel and a very short incision on the outer lip; callosity on the inner lip very little developed.

6. MOGULIA, Waagen, n. gen. Globular, without a well developed slit-band; mouth oval, outer lip with a shallow angular emargination like in *Forskalia*, inner lip callous. No spiral sculpture.

7. TREMANOTUS, Hall, 1864, Annual Reports of the Regents, University of New York: Eighteenth Report, p. 43. Like *Bucania*, but in place of the slit-band a row of oval openings on the last whorl like in *Polytremaria*. Mouth strongly expanded.

8. TUBINA, Barrande, MS. Very much like *Tremanotus*, but with three rows of openings, instead of one, on which long hollow tubes are placed. Mouth very little expanded. This genus has been recognised a long time since by Barrande, and the name used on labels.

9. WARTHIA, Waagen, n. gen. (Cyrtolithes, Orb., Prodr. I, p. 9, pars, non Conrad). Smooth globular shells without slit-band and a broad tolerably deep rounded sinuosity on the outer lip as in *Platyschisma*; inner lip only very slightly callous. No spiral sculpture.

10. EUPHEMUS, M'Coy, 1862, Carboniferous fossils of Ireland, p. 25 (pars). It is difficult to decide what was originally subsumed by M'Coy under this genus, but after much consideration I am led to consider *Bell. urii*, Flem., as its typical species. The species belonging to this genus are chiefly characterised by more or less numerous spiral folds, which are, however, restricted to the inner whorls. The last whorl is smooth, the aperture contracted. No distinct slit-band is developed. The folds have to be considered as columellar folds. This genus is the one which differs most widely from the general type of the *Bellerophontes* and has chiefly

[1] In 1870 Meek created the genus *Bucanella* for forms more or less related to *Bell. trilobatus*, which is stated to agree with *Bucania* in all respects, except in two points, absence of an enlarged aperture and of a slit-band. *Bell. trilobatus*, however, in certain varieties, very closely resembles *Tropidodiscus*, Meek, and thus the propriety of considering these forms as constituting another new genus may be questioned.

given rise to the comparison of the family with the *Heteropoda*, but the shell is thick and heavy, the inner lip callous, as in other *Bellerophontes*.

11. STACHELLA, Waagen, n. gen. Shell more or less globular, unsymmetrical, mostly umbilicated on one side and with a closed umbilicus on the other. The slit-band is distinct, but only very superficially marked, so as to be easily effused by weathering. The slit in the outer lip seems to be very shallow. The unsymmetric development of the shell in this genus is not produced by accidental deformity, but has been regularly observed in many species by Stache and by myself. No species with spiral sculpture has been observed up to the present.

12. BELLEROPHINA, Orb., 1843, Paléont. Franç., Terr. crét., Vol. II, p. 410. Shell smooth, globular, without slit-band and with shallow emargination in the outer lip, slightly unsymmetrical.

A genus which only very doubtfully can be counted with the *Bellerophontidæ* is—

CYRTOLITES, Conrad, 1838, Ann. Geol. Rep., New York, Hall: Palæont. of New York, I, pp. 188 and 308. The whorls are either only just touching each other or entirely disjoined; they are oval in their section and provided with a very high and sharp keel. It remains doubtful whether the aperture had any emargination. The shell seems to be rather thin. These shells might, after all, be *Heteropoda*, as the shell seems rather light and bears no callosity of any kind. The same is the case with *Carinaropsis*, Hall, and other badly known genera. Mons. d'Orbigny has applied the name of *Cyrtolites* quite arbitrarily to different forms of true *Bellerophontidæ*. Another very doubtful genus is *Microceras*, Hall, which seems to be founded only on embryonic volutions of *Bellerophontes*.

Other genera which have been considered very frequently to belong to the family have been removed from it already by Stoliczka. These are *Porcellia*, Leveillé, and *Ecculiomphalus*, Portl. (*Serpularia*, Roem., *Phanerotinus*, Sow.), the former of which has been united by Stoliczka with the *Pleurotomaridæ*, the latter with the *Solaridæ*.

All the genera which I have enumerated are of strictly palæozoic distribution, and barely any species of *Bellerophontes* has been found up to the present in even triassic strata, only *Bellerophina* is cretaceous.

It is very possible, or even probable, that we unite in the family *Bellerophontidæ* rather different things. There are also other families of Prosobranchiata in which symmetrical shells might occur, and some of the shells described by Hall, in which no slit-band exists, and in which also no emargination on the mouth has been observed, might be as well symmetrical *Naticidæ*, *Solaridæ*, or such like. But it will be very difficult to find any proof for such a supposition.

Genus: BELLEROPHON, Montfort.

According to the definition given above, this genus is composed of symmetrical shells coiled in one plane, generally of more or less globular form, with a distinct slit-band running along in the middle of the convex part of the inflated whorls. The surface of the shell is only covered by distinct striæ of growth, which run from the umbilical region in an approximately radial direction, but more or less backwards to the exterior part of the whorls, where they are abruptly deflected backwards on the margin of the slit-band. Besides the striæ of growth there is no other sculpture present on the surface of the shell. The aperture is more or less reniform, the outer lip with a rather deep and tolerably narrow incision, the inner one expanded and very much thickened, a more or less strongly developed callosity covering the whole anterior part of the preceding whorl and the umbilical region.

The shells belonging to this genus are rarely umbilicated, generally the umbilicus is covered up by a thick callosity, which thickens very much the margins of the outer lip, where it unites with the inner one.

The number of forms in the palæozoic deposits of the Salt-range belonging to this genus in the restricted sense, is not very large. They can easily be distributed among known groups of forms, which very likely constitute the developmental series.

By Mons. de Koninck three species of *Bellerophon* have been described from the Salt-range: *Bell. jonesianum*, Kon., *Bell. orientalis*, Kon., and *Bell. decipiens*, Kon. Only the first two are really *Bellerophontidæ*, the third is a new Brachiopod of the Order *Thecididæ*, allied to the genus *Pterophloios* (*Bactrynium*), Guemb. I have to add six more species, which I shall describe under the names of *Bell. impressus*, *B. squamatus*, *B. affinis*, *B. politus*, *B. triangularis*, and *B. blanfordianus*.

These species can be distributed in the following groups:—

a. Group of *Bell. hiulcus*, Mart.—
1. *Bell. jonesianus*, Kon.
2. „ *squamatus*, W.
3. „ *impressus*, W.
4. „ *affinis*, W.

b. Group of *Bell. costatus*, Sow.—
5. *Bell. blanfordianus*, W.
6. „ *triangularis*, W.

c. Group of *Bell. conaliferus*, Gdf. (??)—
7. *Bell. orientalis*, Kon.

d. Isolated species—
8. *Bell. politus*, W.

Of these the group of *Bell. hiulcus* is by far the most extensive in time. It begins already in devonian strata with *Bell. lineatus*, Goldf., and is represented by the typical species *B. hiulcus* in the mountain-limestone. *B. hiulcus* is, however, a somewhat doubtful species, and has been interpreted by different authors in very different ways. Whilst De Koninck wishes to retain the name for those forms with a broad, little raised slit-band, D'Orbigny identifies *B. bicarenus*, Lév., with *B. hiulcus*, Mart., and calls those shells which were considered to constitute the species *B. hiulcus* by De Koninck *B. münsteri*, Orb. M'Coy again unites both species, *B. hiulcus* and *bicarenus*, into one species, for which the name *B. hiulcus* remains. I should not like to advocate this latter view. There might be specimens of *B. bicarenus* which in a certain state of weathering very much approach *B. hiulcus*, but there is no doubt that a species exists in which two keels on the sides of the slit-band are never distinctly developed, and which can be distinguished from the doubly carinated one. As to the views of D'Orbigny in comparison with those of Koninck, I feel rather inclined to adopt those of the latter writer; and thus if I speak of *B. hiulcus*, Martin, I always wish to designate by that name the form figured and described by De Koninck.

Higher up in the series of rocks the group of *Bell. hiulcus* cannot be traced very distinctly for a certain distance. Trautschold, in his Monograph of the Upper Mountain-limestone, mentions casts of *Bellerophonts*, which might belong to *B. hiulcus*, but the shell is never preserved, and thus only a very approximate determination of these fossils can be attempted. In the Salt-range deposits the group suddenly developes in a most surprising manner, not less than four species belonging to it appearing at the same time. After that the group reaches up into still higher strata, but only in sporadic species, the last of these, *Bell. jacobi*, Stache, appearing in the *Bellerophon*-beds of the Alps.

The next group, that of *Bell. costatus*, Sow., has a by far less extensive vertical range. I do not know of any species of *Bellerophon* in the devonian period which I should like to bring into closer connection with Sowerby's species. Possibly *Bell. striatus* (Br.), Phillips' Pal. Foss. Devon. (non d'Arch. and Vern.) might belong to the group, but nothing positive can be said without a comparison of original specimens. In the mountain-limestone *Bell. costatus*, Sow., is a very characteristic fossil. It is characterised by a high elevated keel in full-grown specimens, and an umbilicus, which is partly closed by a callosity. The striæ of growth are irregular and strongly bent backwards, meeting the keel or slit-band under an acute angle. In the upper carboniferous limestone of Russia there is a *Bellerophon* which has been quoted by Trautschold as *Bell. costatus*. It is very difficult to decide on the propriety of uniting the specimen figured by Trautschold with Sowerby's species, but from the drawing it appears that the striæ of growth are more regular and less bent backwards than in the typical species of Sowerby.

Rather nearly related to *Bell. costatus*, but yet easily distinguishable from it, is *B. blanfordianus*, W., from the Salt-range. Another species which repeats the

form of the full-grown *Bell. costatus*, very reduced in size, is *Bell. triangularis*, W. Both appear in the same geological horizon. It seems not possible to trace the group yet further up in the series of rocks, as in the Bellerophon-limestone of the Alps no species occurs which could be assigned to the group of *Bell. costatus*.

The relationship of *Bell. orientalis*, Kon., is very doubtful. In his description of the species Mons. de Koninck compares this shell to *Bell. tenuifascia*, Sow., but in this latter the slit-band forms a rather sharp, prominent keel, the striation of the surface is nearly straight, very fine and close, and touches the keel at about right angles. All these characters do not occur in *Bell. orientalis*. This is a sulcated species with excavated slit-band, with heavy shell and the umbilicus mostly closed by a thick callosity. In general form, as it seems, only *Bell. canaliferus*, Gdf., can be compared; but in this species the callosities are absent, and thus it is rather doubtful whether it can be brought in any close connection with *Bell. orientalis*. Some specimens of the latter species even seem not entirely to warrant a separation from *Bell. jonesianus*, and the supposition of *Bell. orientalis* being a deformed state of *Bell. jonesianus* might not be altogether excluded. If, however, the former form is considered to constitute a well defined species, it must be counted with the sulcated *Bellerophonts*, and among these *Bell. canaliferus*, Gdf., is the one with which the Indian shell can best be compared: I thus in a provisional way consider *B. orientalis* as belonging to the group of *B. canaliferus*, Gdf.

The last species of true *Bellerophonts* occurring in the Salt-range belongs to a group of forms which has not been detected up to the present in European strata. Its shell is quite smooth and polished, only with the lens, and with great difficulty, some very fine striæ of growth are observable.

Very remarkable is the circumstance that one group of forms which is very much developed in European upper palæozoic strata, that of *Bell. bicarenus*, Lév., is entirely absent in the Salt-range. Not only is this group of great geological importance in the mountain-limestone of Belgium, but also in the permo-carboniferous strata of Spitzbergen; and in the Bellerophon-limestone of the Alps similar forms occur, which are there numerically about equal in importance to the species belonging to the group of *Bell. hiulcus*.

a. Group of *BELLEROPHON HIULCUS*, Mart.

1. Bellerophon jonesianus, Koninck. Plate XIII, figs. 1, 2.

1863. *Bellerophon jonesianus*, L. de Koninck: Quart. Journ. Geol. Soc., Lond., Vol. XIX, p. 9, Pl. III, fig. 2.
1863. *Bellerophon jonesianus*, L. de Koninck: Foss. Paléoz. de l Inde, p. 14, Pl. III, fig. 2.

The species as characterised by Koninck contains mostly globular shells which are about as high as they are broad. The shell is very thick and covered by not very closely arranged, nearly straight striæ of growth, which are only deflected backwards not far from the keel in the middle of the outer side of the whorls. The keel is mostly only very slightly raised, and sometimes in the same plane as the

surrounding shell, forming only a very distinct slit-band. The breadth of the slit-band is not very considerable. At the mouth of the shell a strong callosity is developed, which covers the small umbilicus almost entirely, and envelopes the upper part of the preceding whorls. The slit at the outer lip of the aperture is narrow and rather deep.

This is the general characteristic of the species, which, however, varies greatly according to age and individual.

The smallest specimen at my disposal is 11 mm. in diameter. It is somewhat higher than broad, and thus laterally slightly compressed. The transverse section of the whorls is semilunar, about twice as broad as it is high. The whorls are nearly entirely involute, no umbilicus, properly speaking, being present, only a slight groove in its place. The shell is very thick and heavy, and covered on its surface by very closely arranged fine striæ of growth, which go in a very regular low arch from the umbilicus to the peripheral part of the whorls, forming an angle of about 60° with the keel. This latter is rather broad and very little raised; it forms a low zone, not entirely flat on the top, but very slightly arcuate. The mouth of the shell is very little callous, and not at all enlarged. The callosity is thickest in the umbilical region.

At a diameter of the shell of about 20 mm. the surface sculpture begins to change. The striæ of growth are further distant from each other and become more and more straight. They reach the keel now under a somewhat less acute angle (about 65°) than in smaller specimens. The keel is still always low and tolerably broad, but without having increased much in absolute breadth, which in the smaller specimen is not quite 1 mm., and in the larger just 1 mm. The striæ of growth can now be observed on the keel as well as on the lateral parts of the shell, forming there a little arch with a backward curve.

From 20 to 40 mm. in diameter, the general features of the shell undergo very little change. In this stage of growth, the keel becomes nearly quite obsolete, being replaced by a flat slit-band, which is in one plane with the other parts of the shell. Different individuals vary somewhat in the arrangement of the striæ of growth, which are rather close in some specimens and more distant in others.

The species seems to be full-grown at a diameter of the shell of about 55 to 60 mm. At this size some of the striæ of growth are transformed into strong irregular folds, which are chiefly so developed in the umbilical region; between these folds finer striæ of growth, also rather irregular, are observable. The flat slit-band becomes again raised, forming a broad and obtuse keel, which terminates at the aperture. The umbilicus is no longer entirely closed, but there remains a deep and narrow slit open. The mouth of the shell is now greatly expanded, chiefly in the umbilical region, where the inner lip is strongly callous and covering the whole anterior face of the inner volution. The expanded lateral parts of the inner lip are broad and reach very far down, and are very thick and massive. The outer lip is sharp and very thin, and thus very rarely entirely preserved. The same

is the case with the emargination on the outer lip, which seems to be deep, narrow, and rectangular, but in none of all the specimens at my disposal is this part of the shell sufficiently well preserved to make a drawing of it.

The internal casts of this species are rather remarkable. They consist of broad depressed whorls, which are, however, never entirely symmetrical. There is a broad tolerably flat space on the peripheral part, which bears three flat spiral grooves, the middle one of which is never in the middle of the peripheral region, but always excentric. The transverse section of the whorls is reniform, but the summit of the outer arch is not placed in the middle, but somewhat on one side. All this shows that the animal which inhabited the shell cannot have been quite symmetrical, the shell only appearing quite symmetrical by being unequally thick in different places.

The umbilicus in the casts is not very large, occupying about the fourth part of the entire diameter of the cast.

The measurements of four specimens, Nos. I, II, and IV from Katwáhi, No. III from Khund Ghât, are as follows :—

	I.	II.	III.	IV.
Diameter of the entire shell	55 mm.	42 mm.	26 mm.	11 mm.
Breadth of the aperture	53 „	40 „	25 „	9 „
Height of the aperture from the top of preceding volution .	18 „	16 „	11 „	4 „
„ „ „ from the upper termination of lateral callosity . . .	30 „	25 „	17 „	6 „
„ „ „ from the lower termination of lateral callosity . . .	45 „	34 „	19 „	8 „
Breadth of the shell at the umbilical region without the lateral callous expansion of the mouth . . .	41 „	31 „	20 „	7 „

Locality and geological position.—This species is very common in the upper division of the Productus-limestone of the Salt-range, but seems at the same time to be restricted to that formation, as only a single doubtful very badly preserved specimen of the species has been detected up to the present in the middle division of the same formation. The species has been found in the upper division of the Productus-limestone at the following localities: at Katwáhi by myself and Mr. Wynne (13 specimens), at Khund Ghât by Mr. Wynne (15 specimens), in the hills east of Katwáhi by myself (1 specimen), at the village of Khura by myself (4 specimens), in the Chitta Wán by myself (1 specimen, cast), at Vurcha by Mr. Wynne and Dr. Warth (4 specimens, 1 cast), at Chidru in the uppermost beds of the Productus-limestone by myself (1 specimen), and at Káfirkot, trans-Indus, by myself (4 specimens). In the middle division of the Productus-limestone one specimen was collected by Mr. Wynne in the hills east of Nursingphoár glen.

Remarks.—This species is very nearly allied to *Bell. hiulcus*, Mart., as has been pointed out by Mons. de Koninck, and already this author has stated the differences to consist in the Indian species being less inflated in its general form and in a narrower and generally more prominent slit-band. To this we may add the greater straightness of the striæ of growth in middle-sized and full-grown specimens, the

lateral parts of the interior lip being much more expanded, and the much more extended callosity, which covers nearly one-half of the preceding whorl. Though the resemblance of *B. hiulcus* and *B. jonesianus* may be very great, yet I think the latter constitutes a well distinguishable species. *Bellerophon jacobi*, Stache, seems to be even more closely allied to our species than *Bell. hiulcus*, but the original specimen is so indifferently preserved that an exact comparison seems barely possible. The great thickness of the shell on the peripheral part of the specimen is, however, not in favor of an identification of the two species. Only in the inner whorls is the outer part of the shell similarly thick in *Bell. jonesianus*, but on the last whorl, where no callosity has contributed to thicken the shell, this part is always comparatively thin. Thus we may, until better materials for comparison are procurable, safely distinguish between the two species.

2. Bellerophon squamatus, Waagen, n. sp. Plate XII, fig. 9.

Though there is no very well preserved specimen of this species, yet the specimens which exist show so peculiar features that the creation of a separate species may be justified.

The general form of the shell is elongated oval, a good deal higher than broad. The whorls are inflated, perfectly involute, leaving no umbilicus open. The aperture is semilunar, the outer lip thin and sharp, the inner one slightly callous, the lateral parts of it being not very strongly expanded and thickened, but yet sufficient to cover up the whole umbilicus by its callous thickenings, except a narrow slit which remains open. Only about a third part of the whole height of the inner volution, as visible in a front view of the specimen, is covered by the mesial callosity of the inner lip.

The surface sculpture of the shell is very characteristic. It consists of very far apart strong squamose striæ of growth, which are almost entirely straight, and only very little deflected backwards near the keel. This latter is very broad and very little raised, and covered by squamose striæ of growth, slightly reversedly arched.

The mouth of the shell is not sufficiently well preserved to ascertain of what shape or how deep the incision of the outer lip corresponding to the slit-band on the keel may have been.

The casts of this species have slightly inflated whorls, not very broad, with an arched peripheral part, bearing no spiral grooves, and an umbilicus which is tolerably wide, occupying a little less than one-third of the whole diameter of the cast.

One otherwise very badly preserved specimen of this species, collected by Dr. Oldham at Chidru, is very interesting on account of the structure of its shell, which is well observable. The whole thickness of the shell consists of very thin lamellæ, which even now in some places retain a dull somewhat pearly lustre. It is therefore very probable that the greater part of the thick shell of the Bellerophonts consisted of mother-of-pearl substance.

The measurements of two specimens, No. I from Chidru, with preserved shell, No. II from Vurcha, a cast, are as follows:—

	I.	II.
Diameter of the specimen	50 mm.	40 mm.
Thickness of the specimen at the mouth	40 „	23 „
Height of the aperture from the top of the preceding whorl	18 „	19 „
„ „ „ umbilical margin	...	22 „
„ „ „ upper margin of the lateral callosity	29 „	..
„ „ „ lower margin of the lateral callosity	45 „	...
Diameter of the umbilicus	...	11 „

Locality and geological position.—This species is rather rare in the Productus-limestone of the Salt-range, and seems to be restricted to the middle division of that formation. It has been collected in the compact limestone of that division of the Productus-limestone at Chidru by Dr. Oldham (2 specimens), at Vurcha (?) by Dr. Warth (1 cast), and at Bilot (?) trans-Indus by Dr. Verchere (1 cast).

Remarks.—Though this species like the preceding one seems to be very nearly related to *Bell. hiulcus*, yet a distinction as well from this species as from *Bell. jonesianus* is not very difficult.

From *Bell. hiulcus* our species can be distinguished by the much more compressed form and the much stronger and straighter striæ of growth. A point of similarity, on the contrary, consists in the little-developed lateral callous expansion of the interior lip and the very short callosity covering the preceding whorl, which is alike in *Bell. hiulcus* and *Bell. squamatus*.

The same characters, which serve to distinguish the two species just mentioned, are also useful for the distinction between *Bell. squamatus* and *Bell. jonesianus*. But besides the more compressed form and the squamose striæ of growth, there is also the little-developed callosity and the very reduced expansion of the lateral parts of the inner lip, which form distinctive characters in the present species. The casts of *Bell. jonesianus* and *Bell. squamatus* are entirely different. In the latter species the whorls of the cast are much more slender, and the umbilicus wider, and the peripheral part is not flattened, but regularly arched.

Thus the forms which I subsume under the name of *Bell. squamatus* seem to constitute a well distinguishable species which is characteristic of the middle region of the Productus-limestone.

3. Bellerophon impressus, Waagen, n. sp. Plate XII, fig. 5.

This is the largest species of *Bellerophon* that occurs in the palæozoic deposits of the Salt-range.

The general form of the shell is broadly oval or compressed globular, very little higher than broad. The whorls are broad, depressed, and somewhat trapezoidal in their section; their peripheral part is distinctly flattened or even slightly excavated. The flattened part is limited on both sides by broadly rounded edges.

The lateral parts of the whorls are also flattened and ascending towards the umbilical region, where the greatest transverse diameter of the whorls is situated. The umbilicus is almost entirely closed, only a very narrow, but deep slit-like groove being left open.

The surface sculpture is not well observable on the specimens at my disposal, but, on the whole, seems to be much like that on *Bell. jonesianus*. Full-grown specimens of the present species have the surface sculpture transformed into broad and prominent folds near the umbilicus, which are spread out near the peripheral part of the shell into broad and low irregular undulations. On this latter part of the shell the most remarkable feature consists, besides in its being flattened or even excavated, in the absolute absence of every trace of a keel even in perfectly full-grown specimens. The slit-band is everywhere quite smooth and flat and barely traceable.

The mouth of the shell is very much expanded and trumpet-shaped. The outer lip is sharp and thin, with a very deep and narrow somewhat rectangular emargination in the middle; the inner one is very much thickened and expanded, the expansion taking place in a somewhat horizontal direction, so that it reaches with its lower termination nearly to the peripheral part of the inner volution. Laterally the expansion is not so very prominent. The callosity very thickly envelopes the upper part of the inner volution and forms an indistinct rounded prominence or ridge across it just within the mouth of the shell. From this ridge the callosity crosses over to the lateral expansion of the inner lip, thickening it to a very large extent, considerably narrowing the mouth of the shell.

The dimensions of the typical specimen of this species are as follows:—

Diameter of the shell	65 mm.
„ of the umbilical groove	5 „
Greatest breadth of the shell	62 „
Breadth of the shell without the lateral expansions of the mouth	47 „
Height of the mouth from the top of preceding whorl	23 „
„ „ „ upper margin of the lateral callosity	35 „
„ „ „ lower margin of the lateral callosity	51 „

Locality and geological position.—The beautifully preserved specimen which has served for the definition and description of this species was collected by Dr. Oldham in the upper division of the Productus-limestone at Chidru; two other specimens which were found by Mr. Wynne in the same beds at Khund Ghât I can only doubtfully assign to this species, as they are too indifferently preserved to allow of a quite certain determination.

Remarks.—Much more deviating from the type of *Bell. hiulcus* than the two preceding species is the present one. Though the general form of the shell, the surface sculpture, and the form of the emargination in the outer lip clearly indicate the relationship of *Bell. impressus* to the type species of the mountain-limestone, yet the excavated peripheral part of the shell, the tolerably narrow slit-band, the compressed form of the whole shell, make a distinction between the two very easy.

Bell. jonesianus, which is, next to *Bell. hiulcus*, most nearly allied to the present species, is easily distinguishable by its rounded peripheral part of the shell, a more globular form, and a lateral callous expansion of the interior lip, which is more directed downwards and thus gives to the front view of the shell an entirely different appearance.

Bell. squamatus is similarly compressed as *Bell. impressus*, but the callosity on the interior lip is almost entirely wanting, and there exists no expansion of the mouth, and in consequence of this also no laterally projecting parts of the interior lip.

4. Bellerophon affinis, Waagen, n. sp. Plate XIII, fig. 3.

The general form of the shell is compressed globular, and, on the front view, more or less hexagonal. The whorls are very broad, but not very much depressed. They possess a trapezoidal section with a distinctly flattened peripheral part on which a very distinct obtuse keel is strongly developed. The flattened peripheral part is limited on both sides by rounded ridges, which pass very gradually into the well-rounded lateral parts of the shell. The umbilicus is entirely closed, not even a narrow slit remaining open.

The surface sculpture of the shell consists in very sharp, not very distant ribs or striæ of growth, which are not quite straight, but show a slight curve towards the front. Near the slit-band they are but very slightly deflected backwards. The slit-band is very distinct and very narrow, occupying only the very top of the prominent keel; it is crossed by numerous small reversedly arched striæ of growth.

The mouth of the shell is reniform, slightly expanded, with a thin and sharp exterior lip, which bears a deep and narrow rectangular emargination in the middle. The interior lip is callous, the callosity covering nearly one-half of the last whorl, so that on the front view the sculpture of the shell can only be seen at the lower margin of the figure. The lateral expansions of the interior lip and callosity are tolerably strongly developed and reach far down; they are not very strongly thickened.

The changes this species undergoes in the course of its growth are not very considerable. The keel on the peripheral part is already distinctly developed in the shell at a very small size; later on the flattened condition of the peripheral part of the shell appears. Like in *Bell. jonesianus* the striæ of growth are arranged more closely and show a stronger curve towards the front in younger than in older specimens.

The dimensions of a well preserved specimen are as follows:—

Diameter of the shell	53 mm.
Breadth of the mouth	46 „
„ „ shell without the lateral expansions of the mouth	34 „
Height of the mouth from the top of the preceding volution	18 „
„ „ „ „ upper margin of the lateral callosity	30 „
„ „ „ „ lower termination of the lateral callosity	43 „

Locality and geological position.—This species seems to be restricted entirely to the upper division of the Productus-limestone. It has been collected in these beds by myself at the village of Khura (5 specimens), at Katwáhi (1 specimen), and at Kufri (5 specimens), and by Mr. Wynne at Katwáhi (5 specimens), and at Khund Ghât (1 specimen).

Remarks.—The general form of this shell recalls already to a certain extent the form of the species belonging to the group of *Bell. costatus*, Sow., but nevertheless its affinity to *Bell. jonesianus*, Kon., is very great. That this shell does not belong to the group of *Bell. costatus* appears clearly from the direction of the striæ of growth, which are very little curved, and from the emargination of the outer lip, which is deep and rectangular.

The present species is distinguishable from *Bell. jonesianus*, Kon., by its more compressed form, its flattened peripheral part, the strong keel it bears, and by the less straight striæ of growth. The somewhat thicker varieties of *Bell. affinis*, W., however, are not always easy to distinguish from *Bell. jonesianus*, Kon., only the flattened peripheral part with the thick keel on it may then be distinctive.

Bell. impressus, W., is, in this respect, more nearly allied to the present species than *Bell. jonesianus*, Kon., but in the former species there is never a prominent keel on the excavated peripheral part of the shell, and the mouth is entirely different.

Other species like *Bell. hiulcus*, Mart., *Bell. squamatus*, W., etc., bear only a slighter resemblance to the form here described.

b. Group of *BELLEROPHON COSTATUS*, Sow.

5. Bellerophon blanfordianus, Waagen, n. sp. Plate XIV, figs. 1, 2.

The general form of the shell is strongly inflated, nearly as thick as it is high, with a tolerably large umbilicus on each side. The whorls are broad and depressed, pentagonal in their section. There is a very high prominent keel on the peripheral part of the whorls, the slit-band occupying a flat space at top. On both sides of this keel there are flat zones which slope considerably down towards a rounded edge dividing the peripheral from the lateral parts of the whorl. These latter are not quite vertical, but somewhat turned outwards. The largest transverse diameter of the whorls lies on the obtuse umbilical edges. From there the outline of the whorls passes vertically down to the umbilical suture, forming a very high, vertical umbilical wall.

The surface sculpture is very characteristic. It consists, in middle sized specimens, of fine striæ of growth, very closely arranged. These ascend from the umbilical suture in an oblique line to the umbilical edge, and, bending slightly backwards, cross the lateral parts of the shell in about a tangential direction. At the outer margin, where the lateral and peripheral parts of the shell unite in forming

an obtuse edge, the striæ show a slight curve towards the front, but as soon as they reach the peripheral part of the shell, they are deflected even more strongly backwards so as to unite with the median keel under an angle of about 30° to 40.° The slit-band is situated on the top of the median keel, forming there a flat zone, limited on both sides by sharp lines, and composed of small reversedly arched squamose striæ of growth. (The drawing of the striæ of growth on the keel in fig. 1*b* on Pl. XIV is entirely wrong; fig. 2*b* is correct in this respect).

In full-grown specimens, towards the end of the last volution, the striæ of growth are separated into groups or bundles, forming thus more or less broad and prominent folds.

The mouth of the shell is not much expanded, and more or less hexagonal in shape. The outer lip is thin and sharp, provided in the middle with a very deep angular emargination, which is tolerably wide in front and narrowly angular at its backward termination; its margins are somewhat raised. The inner lip is callous, but the callosity is very thin, and falls easily off, and it does not extend very far over the inner whorl. The lateral expansions of the inner lip are little extensive; they only just occupy the height of the umbilical wall, and show an angular prominence corresponding to the umbilical edge. From this prominence the outline slopes down in an oblique line to the lower termination of the callosity.

This species shows very different characters according to different stages of growth.

The smallest specimen I have for description has not more than 6mm. in diameter. The shell is nearly globular with a very small umbilicus, and the callosity at the aperture almost quite absent. Likewise the lateral expansions of the interior lip are not developed. The transverse section of the whorls is semilunar, without any edges or angles. The surface sculpture consists of numerous, fine, closely arranged striæ of growth, which are strongly arched and strongly deflected backwards, chiefly near the middle of the peripheral part of the whorls, where they at last touch each other, and so form a distinct revolving line on each side of the slit-band, whereby this latter is limited laterally. The slit-band lies perfectly in one plane with the remainder of the shell surface; it is not broad, and is covered by numerous reversedly curved striæ of growth.

At a diameter of the shell of about 20mm., a very slight depression of the peripheral part begins to appear, limited on both sides by very indistinct obtuse ridges. The keel is raised, but not very prominent. The umbilicus is comparatively larger than in the smaller specimens, but no umbilical edge is yet developed. The striæ of growth begin to show the sigmoidal curve, which is so distinctly observable in larger specimens. The callosity at the mouth is somewhat better developed, but the lateral expansions of the inner lip are still very small.

At 30 mm. diameter all characters of the species are perfectly expressed, and from this size up to 50 mm. diameter (the largest specimen observed) the only changes observable consist in the plication of the surface, as has been indicated above.

The measurements of three specimens, Nos. I and II from Khura, No. III from Chidru, are as follows:—

	I.	II.	III.
Diameter of the shell	43 mm.	20 mm.	6 mm.
„ „ „ umbilicus	8 „	2·5 „	1 „
Greatest breadth of the mouth	37 „	18 „	6 „
Breadth of the mouth at the umbilical suture	23 „	12 „	4 „
Height of the mouth from the top of preceding whorl (?)	18 „	8 „	3 „
„ „ „ „ from the upper margin of lateral callosity	26 „	13 „	4·5 „
„ „ „ „ from the lower termination of lateral callosity	35 „	16 „	

Locality and geological position.—This species is one of the rarer *Bellerophonts* of the palæozoic deposits of the Salt-range, and occurs there chiefly in the upper division of the Productus-limestone, one single doubtful specimen having been found by me in the upper region of the middle division of the same formation, west of Khura. In the upper division of the Productus-limestone the species has been collected by myself at the village of Khura (2 specimens), on the mountains east of Katwáhi (2 specimens), on the road from Katwáhi to Sháhpur (1 specimen), and at Chidru (1 specimen); by Mr. Wynne it has been found at Khund (1 specimen), at Khund Ghât (2 specimens), and at Kufri (1 specimen).

Remarks.—This species is in every respect most nearly allied to *Bell. costatus*, Sow. The whole development of the species is exactly like that of the English mountain-limestone shell, but all the stages of growth are much reduced in size in our species: *Bell. costatus* exhibits at a diameter of 30 mm. the same characters which a specimen of 6 mm. diameter of our species possesses, whilst at 30 mm. *Bell. blanfordianus* has already all the characters of the full-grown shell developed.

It is not difficult to distinguish the full-grown specimens of the two species. The largest size of *Bell. blanfordianus* that has hitherto been observed is 50 mm. in diameter, whilst of *Bell. costatus*, specimens of 100 mm. diameter are not rare. Besides by the more reduced size, the present species can also easily be distinguished from *Bell. costatus* by its very little developed callosity, its broader peripheral part, and the characteristic sigmoidal curve of its striæ of growth.

Bell. blanfordianus thus seems to constitute a well distinguishable species, which stands, however, in rather close connection to *Bell. costatus*, Sow.

Young specimens of the present species resemble also more or less similar sized specimens of *Bell. jonesianus*, Kon., but these can easily be distinguished by the more strongly curved striæ of growth and the presence of an umbilicus in *Bell. blanfordianus*.

6. Bellerophon *cf.* blanfordianus, Waagen. Plate XIV, figs. 3, 4.

In the lower division of the Productus-limestone of the Salt-range there occurs a species of *Bellerophon* which is most nearly allied to *Bell. blanfordianus*, but which yet seems to be too far different from it to allow of a direct identification with that species.

There was collected by me a cast of a middle size *Bellerophon* 30 mm. in diameter, much deformed by compression, in the lowest beds of the compact Productus-limestone at Katta (Bed No. 13 of the section there), which bears a strong prominent keel and has a large umbilicus, and which thus might best be compared to *Bell. blanfordianus*.

Another specimen, provided with its shell, was collected by me in the Nila Wán in the lowest beds of the Productus-limestone series. This specimen has only 10 mm. in diameter, is provided with its shell, and shows already the general form of the full-grown specimens of *Bell. blanfordianus*. It has a strongly prominent keel, somewhat pentagonal whorls, and a rather large umbilicus.

It does not seem quite safe to unite these specimens indiscriminately with *Bell. blanfordianus*, neither are the materials at hand sufficient to recognise the characters of a new species. Among the species hitherto described, they can, however, certainly best be compared to *Bell. blanfordianus*, W.

7. Bellerophon triangularis, Waagen, n. sp. Plate XII, figs. 7, 8.

The general form of the shell is thick lenticular, not very much higher than broad. The whorls are thick, inflated, with a somewhat triangular section, well rounded everywhere, except on the top of the peripheral part, which is provided with a high prominent keel. They are not entirely involute, but there remains a very small umbilicus open, which is, however, not surrounded by a distinct umbilical wall.

The surface-sculpture consists of very fine, extremely numerous striæ of growth, which are prominent and slightly lamellar. They pass in a strong backward curve from the umbilicus to the keel, with which they unite under an angle of about 25°. The keel is flattened on the top, limited on both sides by two angular edges, and covered by numerous somewhat squamose reversedly curved striæ of growth. The striæ of growth on the surface of the shell are less numerous in smaller than in larger specimens.

The mouth is semilunar in shape. The outer lip is extremely thin and fragile, and therefore only very rarely preserved entire. It is provided in the middle with a very deep angular emargination, which is widely open in front and acutely angular behind. The inner lip is callous, but not very strongly so. The callosity extends over the greater part of the anterior half of the inner volution. The lateral expansions of the inner lip are very moderate, they are, however, reflected, so as to cover partly the umbilicus. The callous thickening on these lateral wings is not considerable.

In this shell already in very early stages of growth the perfect form of the species is developed. The specimens of 10 mm. in diameter show already all the characteristic peculiarities of the species, and the peripheral keel is as high

as in full-grown specimens. Only specimens of about 5 mm. diameter have no prominent keel as yet.

The species never attains any considerable size; specimens of 30 mm. diameter are the largest that have been observed up to the present.

The measurements of two specimens, No. I from Khura, No. II from Katwáhi, are as follows:—

	I.	II.
Diameter of the shell	30 mm.	22 mm.
„ „ umbilicus	2 „	2 „
Breadth of the aperture	24 „	19 „
„ „ „ at the umbilical suture	17 „	13 „
Height of the aperture from the top of the preceding whorl	13 „	8 „
„ „ „ „ the upper margin of the lateral callosity	18 „	15 „
„ „ „ „ the lower termination of the lateral callosity	23 „	18 „

Locality and geological position.—The species is entirely restricted to the upper division of the Productus-limestone, and is not at all rare in those beds. It has been collected in these strata by myself at the village of Khura (3 specimens), west of that village (1 specimen), at Kufri (2 specimens), at Jabi above the Cephalopoda bed (1 specimen), at Chidru (5 specimens), at Musa Khel (1 specimen), and trans-Indus at Káfir Kot (2 specimens). By Mr. Wynne it has been found at Khund Ghât (22 specimens) and at Katwáhi (4 specimens).

Remarks.—This is a very characteristic little species, which can be easily recognised. Like the preceding species this one also belongs to the group of *Bell. costatus*, but the form of the present shell is entirely different from that of *Bell. blanfordianus*. The two species can be most easily distinguished in the smallest individuals by the prominent keel, which is already present in very young specimens of *Bell. triangularis*, whilst it is absent in similarly sized individuals of *Bell. blanfordianus*. The full-grown specimens of the former species are distinguishable from specimens of a similar size of *Bell. blanfordianus* by the well rounded lateral and peripheral parts of the shell, and the very small umbilicus, which is partly covered up by the reflected lateral expansion of the inner lip.

Bell. triangularis repeats exactly on a very small scale the general form of the full-grown specimens of *Bell. costatus*, Sow. The two species are, moreover, distinguishable not only by the size, but the Indian shell has also a much less developed callosity on its mouth and a much smaller umbilicus, and thus I do not think that any body will advocate the identification of the present species either with *Bell. blanfordianus* or with *Bell. costatus*. Among other European carboniferous species *Bell. sowerbyi*, Orb., seems to be rather nearly related to the present species, but in the Indian shell the striæ of growth are more closely arranged, and the small umbilicus is nearly closed by the lateral callosity, whilst it remains open in *Bell. sowerbyi*. Besides this the size of the two species is also different. *Bell. tenuifascia*, Sow., might also be compared, but it is easily distinguishable from the present species by its much broader form and its sharp very narrow keel.

c. ?? Group of *BELLEROPHON CANALIFERUS*, Gdf.

8. Bellerophon orientalis, Koninck. Plate XIII, fig. 5.

1863. *Bellerophon orientalis*, Kon.: Quart. Jour. Geol. Soc., Lond., Vol. XIX, p. 9, Pl. III, fig. 3.
1863. *Bellerophon orientalis*, Kon. : Foss. Paléoz. de l' Inde, p. 15, Pl. III, fig. 3.

This is an exceedingly rare species, and among the very ample materials that have been collected by the Geological Survey, there are only a few rather badly preserved specimens which might be assigned to it.

The general form of the shell is compressed globular, with broad inflated whorls, which are well rounded everywhere and do not envelope each other entirely, but leave a small umbilicus open. The shell is not very thick; the surface sculpture consists in very irregularly arranged, strongly curved striæ of growth, which start from the umbilicus in about a radial direction, and are strongly deflected backwards on the peripheral part of the shell, so as to unite with the slit-band under an angle of about 30°. These striæ of growth are very little prominent, and appear in some parts of the same specimen as if bundled together; in other parts they are rather far distant from each other.

The slit-band is very narrow, very little excavated, and bordered on both sides by sharp angular edges. The rather distant reversedly curved striæ of growth are well visible at its base.

The mouth is very badly preserved in all the specimens at my disposal. So much, however, can be observed that its general shape is broadly reniform, and that the exterior lip is thin and sharp. The form and length of the emargination could not be observed. The inner lip is not very strongly thickened by the callosity. The lateral expansions are very moderate, not much thickened and not reflected upon the umbilicus. The callosity extends, however, nearly down the anterior half of the last whorl.

The measurements of a specimen from Katwáhi are as follows:—

Diameter of the shell	22 mm.
„ „ umbilicus	3 „
Greatest breadth of the aperture	18 „
Breadth of the aperture at the umbilical suture	13 „
Height of the aperture from the top of the preceding whorl	8 „
„ „ „ „ upper margin of the lateral callosity	12 „
„ „ „ „ lower „ „ „ „	16 „

Locality and geological position.—There are only four specimens in the Salt-range collection, which with any certainty can be attributed to this species; one of them was collected by Mr. Wynne at Katwáhi in the upper division of the Productus-limestone, two others were found also by Mr. Wynne in the upper Productus-limestone at Khund Ghât, and the fourth was collected in the same beds by myself at the village of Khura. A very large specimen of 40 mm. diameter

which I found in the upper Productus-limestone at Nanga belongs very likely also to this species, as its slit-band is also excavated and it possesses a small umbilicus, but the shell is somewhat deformed by an injury the animal had received during life-time, and thus this specimen might possibly also be a deformed *Bellerophon jonesianus*.

Remarks.—The distinction of this species is not very difficult, as the excavated slit-band and the small umbilicus are very easily observable characters.

By Mons. de Koninck this species has been compared to *Bell. tenuifascia*, Sow., and it cannot be denied that the two species bear a great resemblance to each other, only the peripheral sharp keel, which is so well developed in *Bell. tenuifascia*, is replaced in the Indian species by a narrow excavated slit-band.

If we take only the peculiarities of the slit-band into consideration, we must compare the present species to *Bell. canaliferus*, Gdf. The general form of this species resembles somewhat that of *Bell. orientalis*, but the lateral callosities are always much less strongly developed than in the Indian shell.

It must, however, not be overlooked that *Bell. orientalis* also resembles greatly *Bell. jonesianus*, Kon., and that the great irregularity of the striæ of growth, and the somewhat varying direction of the narrow slit-band, often make one doubt whether *Bell. orientalis* may not be after all only a deformed variety of *Bell. jonesianus*.

d. ISOLATED SPECIES.

9. Bellerophon politus, Waagen, n. sp. Plate XII, fig. 6.

The general form of this little species is very thick lenticular, with broad inflated whorls, which envelope each other entirely, so that the umbilicus is only indicated by a very small but deep impression or groove. The whorls are broadly sharpened on their peripheral part, a tolerably broad prominent keel occupying the summit, on both sides of which are flat sloping planes. The laterally most prominent part of the whorls is very near the umbilical region, and from there in a short curve the lateral parts of the whorls bend down to the deep groove, which replaces the umbilicus.

The surface of the shell is entirely smooth and polished; only when the light is reflected very favorably, capillar striæ of growth are observable, the direction of which can with difficulty be followed. The summit of the keel is as smooth as the rest of the shell, and no striæ of growth are observable on it.

The mouth is broadly heart-shaped, but in none of the specimens is this part of the shell entirely preserved. The outer lip seems to be thin and sharp, the emargination in it is, however, always broken away, and thus its shape and extent cannot be fixed. The inner lip is very slightly thickened or callous, the callosity extending not very far over the preceding whorl. The lateral callous expansions of the inner lip are very little prominent, not much thickened and not reflected.

The dimensions of a specimen from Khund Ghât are as follows:—

Diameter of the shell	20 mm.
Greatest breadth of the mouth	19 „
Breadth of the mouth at the umbilical groove	12 „
Height of the mouth from the top of the preceding whorl	8 „
„ „ „ „ upper margin of the lateral callosity	11 „
„ „ „ „ lower margin of the „ „	16 „

The species seems not to attain any large size, the specimen of which the measurements have been given above being the largest that has been observed up to the present.

Locality and geological position.—There are altogether only three specimens of this species in the Salt-range collection, all three of which were found in the upper division of the Productus-limestone; two by Mr. Wynne at Khund Ghât and one by myself at Khura.

Remarks.—The most conspicuous character of the specimens here described is the polished surface of their shell. This character, however, seems not to be quite trustworthy, as the polished condition might be the result of peculiar preservation of these fossils, and it is therefore necessary to look out for other characters of distinction if we wish to compare the present species with other similar shells. In this respect the peculiar form of the mouth and of the transverse section of the whorls are perfectly distinctive. There is no other species in the palæozoic deposits of the Salt-range which would have similarly depressed whorls, and a peripheral part of the shell sloping on both sides from a high elevated keel to the lateral parts of the whorls, and which would have these lateral parts so very narrowly rounded, as is the case in the present species.

Of not Indian species *Bell. vigilii*, Stache, and *Bell. tenuifascia*, Sow., might be compared. Chiefly the former seems to be nearly related, but it has a much more compressed general form, and thus certainly represents a different species. *Bellerophon tenuifascia* has similarly depressed whorls, but the umbilicus remains open, except in quite full-grown specimens about 40 mm. in diameter, and the keel is sharp and very narrow, both being characters which make a distinction from *Bell. politus* easy. *Bell. plicatus*, Ryckh., has the umbilicus closed, but in the other points it differs from our species by the same characters as *Bell. tenuifascia*, Sow.

Thus the present species constitutes a well distinguishable new form, the relations of which to other species can, however, not easily be ascertained until a larger series of specimens have been examined, in order to elucidate the one point in the character of this shell—whether the polished surface exhibited by the specimens at present available be a character connected with the specific distinctness of the form, or whether this is only an accidental peculiarity, caused by an exceptional preservation of the specimens in hand.

Genus: BUCANIA, Hall.

The genus as proposed by Hall ought to have contained shells coiled in one plane, with a large umbilicus on both surfaces, and with whorls sharply angular on both sides. The genus has been compared by Hall to *Porcellia*, from which it seemed to be chiefly different by its angular whorls. It was, however, soon evident that no proper limit could be drawn between *Bucania* and *Bellerophon*, and thus it appeared that the affinity between *Bucania* and *Bellerophon* was greater than that between the former genus and *Porcellia*. Since this has been recognised, most authors have been of opinion that *Bucania* and *Bellerophon* ought to be considered as identical.

Nevertheless, if we examine attentively those forms which were united by Hall under the former name, we cannot deny that most of them have a very peculiar appearance, differing widely from the form that is generally exhibited by the *Bellerophonts*. The most important character for the classification seems, however, not to consist in the large umbilicus, which is also exhibited by some typical *Bellerophonts*, but in the spiral striation, which is in most species well developed. Also the first species quoted by Hall is such a spirally striated one, and we may thus safely retain the name for the spirally striated species.

These forms have several peculiarities in common, which may well serve for characteristics of the genus, and we may thus give the following amended definition of the genus.

The *Bucania* are shells spirally coiled in one plane, with generally a rather thin shell and a spiral surface sculpture consisting of numerous very fine ribs, which are crossed by fine striæ of growth and thus appear more or less cancellated. In the middle of the peripheral part of the shell a distinct slit-band is developed. Laterally there is nearly always a more or less wide umbilicus present. Mouth generally simple, sometimes expanded, inner lip thickened, but seldom strongly callous, outer lip sharp, with a more or less strongly developed median emargination.

According to this definition of the genus, those forms for which M'Coy has proposed the name of *Euphemus* will also belong for the greater part to the genus *Bucania;* but nevertheless the genus *Euphemus*, M'Coy, cannot be considered as entirely identical with the genus of Hall as defined by me, as there ought to exist no slit-band in *Euphemus*, and as also *Bellerophon urii* is considered as an *Euphemus* by M'Coy, which cannot be included in the genus *Bucania*, but which is equally well distinct from *Bellerophon*. For this form and those allied to it the name *Euphemus* will have to be retained.

The forms with very much expanded mouth like *Bell. interlineatus*, Portl., *Bell. depressus*, Eichw., etc., might possibly constitute a separate genus, but the materials at hand are not sufficient to assert this with any accuracy.

Among the materials from the Salt-range there are four species which, I think, must be assigned to the genus *Bucania*. These are *Bucania kattaensis*, W., *B. angustifasciata*, W., *B. integra*, W., and *B. ornatissima*, W.

Of these species the first occurs in the lower division of the Productus-limestone, the others in the upper division of the same formation.

I am sorry to say that only one species of all the Salt-range forms can be compared to a European shell. This is *Buc. kattaensis*, W., which seems to be rather closely related to *Buc. decussata*, Flem. The others seem to be more or less isolated species as far as our knowledge extends up to the present; or they recall to a certain extent American forms: thus, *Buc. ornatissima* can be compared only to *Buc. montfortiana*, Norw. and Pratt.

Some of the Salt-range specimens seem to belong to that section of the genus with rapidly expanding mouth like *Buc. interlineata*, Portl., but all the specimens are not sufficiently well preserved to assert this positively.

1. Bucania kattaensis, Waagen, n. sp. Plate XIV, fig. 6.

The general form of the shell is broadly globular, slightly broader than it is high. The whorls seem to be very few in number, very rapidly increasing in height, and possess a broadly oval section. They do not envelope each other entirely, but leave a small and deep umbilicus open. In the middle of the peripheral part of the shell there is a very distinct slit-band, rather broad, but very little elevated, and flattened on the top.

The whole shell is covered by very closely arranged, but very irregular fine spiral striæ. There are generally two or three finer striæ intercalated between two stronger prominent ones; they increase slowly in strength as the shell progresses in size, and then have other finer lines between them. This spiral striation begins already within the umbilicus and extends over the whole surface of the whorl, the slit-band included. On this latter part of the shell, the striæ are less distinct, and very closely arranged; I count eight or ten on it. There is also one of them situated on each side of the flattened part of the slightly raised slit-band, causing an angular margin to be formed by which the slit-band is limited on each side. As the growth of the shell progresses, the spiral striation disappears more and more on the slit-band.

This whole system of spiral striation is crossed by very numerous and distinct striæ of growth, intersecting the former at about right angles. They proceed from the umbilicus over the sides of the whorls, forming a low arch directed towards the front, and, on reaching the slit-band, are deflected suddenly backwards, crossing the latter in a low reversed arch, and become more strongly marked and more irregular than on the whole remaining surface of the shell.

By these two systems of sculpture the whole surface of the shell appears beautifully reticulated or cancellated.

The shell is very thin and fragile, and only in the umbilical region it is considerably thickened.

The general form of the mouth of the shell is broadly reniform, the outer lip

being thin and sharp, the inner one forming a tolerably strong callosity, which most trongly thickens that part of the shell surrounding t he umbilicus. The lateral expansions of the mouth seem to be large and prominent, but in our only specimen they are nearly quite broken away. The emargination in the outer lip seems to have been broad, but not very deep.

The specimen is too much broken to give exact measurements.

Locality and geological position.—The only specimen of this species was collected by myself at Katta in the lower division of the Productus-limestone (Bed No. 9 of the section in my note book) in a micaceous, calcareous sandstone.

Remarks.—There is but very little doubt that *Buc. kattaensis* belongs to a group of forms of which *Buc. decussata*, Flem., must be considered as type. The misfortune is that it seems to be extremely difficult to find out which form ought to be considered as representing Fleming's species. *Buc. decussata* has been quoted already frequently from devonian strata, and is considered to occur in the same varieties in the carboniferous period, but if one compares the different figures that have been given of this species, it appears highly probable, that very different things have been subsumed under the designation of *Buc. decussata*, Flem. It is not possible for me here to unravel every point connected with this question, as I have not sufficient materials from the devonian and mountain-limestone formations, but it seems more than probable that we have to deal here with a developmental series, the different members of which can well be distinguished.

As to *Bucania kattaensis* it can be distinguished from all the shells that have hitherto been figured under the names of *Buc. decussata*, Flem., *striata*, Flem., *elegans*, Orb., or *clathrata*, Orb., by its exceedingly broad slit-band, the somewhat finer spiral striation, and the more rapidly increasing whorls.

A species which also bears a great resemblance to *Buc. kattaensis* is *Buc. marcouiana*, Gein., from the permo-carboniferous beds of Nebraska city. The latter species can be distinguished from the Indian shell by its more prominent slit-band, larger umbilicus, and its finer spiral striation. On the whole, the two forms might be considered as vicarious species.

2. Bucania angustifasciata, Waagen, n. sp. Plate XIII, fig. 6.

The general form of the shell is thick lenticular, much higher than it is broad. The whorls are inflated, not entirely enveloping each other, but leaving a rather large umbilicus open. They ascend from the umbilical suture in a high perpendicular wall, and are thickest just on the broadly rounded edge which surrounds the umbilicus. From there the surface of the whorl slopes down, being somewhat flattened or impressed, to the broadly rounded peripheral part of the whorl.

This latter part is provided with a not very distinct slit-band, which is very narrow and barely at all raised. It is bordered on both sides by very narrow sharp ridges.

The whole surface of the shell is covered by a very fine spiral striation, in which fine and coarser striæ change very regularly with each other. The vertical umbilical wall is without a spiral striation, also on the slit-band this striation seems to be almost entirely absent. The striæ of growth are much finer and much more numerous than are the spiral ones; they are so fine that they become mostly quite indistinct, and can only be seen in a very favorable light and on parts of the shell which are singularly well preserved. The reticulation of the shell caused by the two systems of sculpture crossing each other is, therefore, very indistinct, and chiefly expressed in a slight granulation observable of the spiral striæ. In the slit-band the striæ of growth are more strongly developed.

The shell is not very thin, but, on the other hand, no part of it is particularly thickened.

The mouth of the shell is reniform, with a thin outer lip and an inner lip only very slightly callous. Lateral expansions do not exist or at least are not preserved in any of the specimens I have for description. The emargination in the outer lip seems to have been very narrow and rather deep.

The dimensions of a specimen from Chidru are as follows:—

Diameter of the shell	9·5 mm.
„ „ umbilicus	2 „
Thickness of the last whorl at the umbilical suture	5 „
Greatest thickness of the last whorl	7 „
Height of the aperture from the top of the preceding whorl	4 „
„ „ „ „ umbilical suture	5·5 „

Locality and geological position.—There have been collected two specimens of this species by myself in the topmost beds of the Productus-limestone at Chidru, and one in the identical beds at the very top of the Productus-limestone formation at Virgal.

Remarks.—There is no species known to me to which the shell here described could be more particularly compared. In its general appearance it recalls to a certain extent the form *Bucania decussata*, Flem., but is easily distinguishable by its larger umbilicus and much finer spiral striation. In these latter characters, it agrees with *Buc. marcouiana*, Gein., from which it differs again by the slit-band, which is strongly raised in the American species, whilst it is on a level with the surrounding shell in *Buc. angustifasciata*. Also *Buc. meekiana*, Swallow, might be compared, but as there is no figure of that species, an exact comparison is impossible.

From *Buc. kattaensis*, W., the present species is distinguishable by the larger umbilicus and much more slowly increasing whorls.

3. Bucania integra, Waagen, n. sp. Plate XIV, fig. 5.

The general form of the shell is thick lenticular, a good deal higher than it is broad. The whorls are much inflated, not enveloping each other entirely,

but leaving a rather large umbilicus open. This latter is surrounded by a rather high vertical wall, which passes without forming any edge into the very narrow lateral parts of the whorl, from whence the surface slopes down to the broadly rounded peripheral part of the shell.

The slit-band is tolerably narrow and very little raised. It is flattened on its top and limited on both sides by sharp edges. If well preserved a very fine spiral striation is also observable on this slit-band. On each side of this latter part of the shell, there is a tolerably broad zone, on which a spiral striation of the shell is well developed. The single striæ are not so fine as on the species described previously, and they are all about equal in strength. The lateral parts of the whorls, however, as well as the umbilical walls, are smooth, only exhibiting very fine striæ of growth. These extend up to the slit-band, crossing the spiral striation of the external part of the shell, but without causing a distinct reticulation to be formed. They are so very fine in comparison to the spiral striæ that the latter seem not much affected by their crossing over them. On the slit-band the striæ of growth are only indistinctly visible.

The shell is very thin everywhere. The mouth is reniform without any callosity on the inner lip, and in the specimens I have for description, without any lateral expansions. The emargination in the outer lip seems to have been moderately broad and not very deep.

The measurements of a specimen from Katwáhi are as follows:—

Diameter of the shell	10 mm.
„ „ umbilicus	3 „
Height of the aperture from the top of the preceding whorl	4 „
„ „ „ „ umbilical suture	5 „
Greatest breadth of the aperture	8 „
Breadth of the aperture at the umbilical suture	5 „

Locality and geological position.—There are two specimens of this species preserved in the Salt-range collection, which were both collected by myself, one at Katwáhi in the upper division of the Productus-limestone, the other at Virgal in the topmost beds of the same formation.

Remarks.—Like the preceding species this one also can be compared to *Buc. decussata* on the one hand and to *Buc. marcouiana*, Gein., on the other. From the first of these the present species can be easily distinguished by its much larger umbilicus and more slowly increasing whorls, from the second by the coarser spiral striation, which does not extend over the lateral parts of the whorls.

From *Buc. angustifasciata*, W., the present species differs by the broader and slightly raised slit-band and by the coarser spiral striation, which is limited to the peripheral part of the shell; from *Buc. kattaensis* it can be distinguished by the more slowly increasing whorls, the coarser spiral striation, and a much narrower slit-band.

4. BUCANIA ORNATISSIMA, Waagen, n. sp. Plate XIV, fig. 7.

The general form of the shell is compressed globular, somewhat higher than broad. The whorls are inflated, depressed, and well rounded everywhere; only on the peripheral part they have an obtuse low keel. They do not envelope each other entirely, but leave a large umbilicus open.

The surface of the shell is ornamented by two distinct systems of sculpture. There are, like in all other species of *Bucania*, thin spiral striæ present, which are in this case rather distant from each other, and in which very regularly a thinner one is situated between two stronger and more prominent striæ. The spiral striation is, as far as can be seen, absent on the slit-band. This latter is very narrow, not broader than the distance between two of the spiral striæ of the stronger sort; it is, at the same time, distinctly raised, forming an obtuse keel, flattened on the top and limited on both sides by sharp edges. The spiral striation does not reach down to the umbilicus, but leaves the lateral parts of the shell free.

The sculpture, which is most strongly expressed on the shell, and which forms the most prominent character of it, consists of distinct broad radial folds, which begin some distance from the umbilicus and pass in a straight line, but slightly directed backwards, to the middle of the peripheral part, where they disappear on reaching the slit-band. Sometimes the latter seems to form a slight node, where the radial folds cross over it. Besides these folds there exist very fine striæ of growth, which are very little curved, following, on the whole, about the direction of the folds, and which cause a slight granulation of the spiral striæ. On the slit-band they are most strongly developed and very numerous.

The shell is very thin, and not thickened in the umbilical region. The mouth of the shell is reniform; the outer lip apparently sharp and thin; on the inner one no trace of a callosity is observable; the whole aperture is, however, too ill preserved to trace its perfect outline. There are no lateral expansions preserved in the specimen I have for description, nevertheless it is probable that such existed, and that the whole aperture was more or less expanded. The emargination in the outer lip, which is well preserved, is very narrow and not very deep.

The dimensions of the only specimen are as follows:—

Diameter of the shell	11	mm.
„ of the umbilicus	3	„
Height of the aperture from the top of the preceding whorl	5	„
„ „ „ „ umbilical suture	6	„
Thickness of the last whorl at the umbilical suture	6·5	„
Greatest thickness of the last whorl	10	„

Locality and geological position.—The only specimen of this species was collected by myself in the topmost beds of the Productus-limestone at Amb.

Remarks.—The general form of this shell is somewhat extraordinary for a *Bellerophont*, as a radial sculpture very rarely occurs in that family. Nevertheless some species have already been described as having a radial sculpture, but then their distinction from *Porcellia* depends almost solely upon the more or less wide umbilicus they possess.

D'Orbigny, in his "Monographie du Genre Bellerophon," described several species which he afterwards in his "Prodrome" referred to the genus *Porcellia*. One of these is *Bellerophon radiatus*, Orb., which by its distant low radial folds very much resembles the species here described, but differs greatly by the much larger umbilicus. The species is a devonian one. The question whether this shell ought to be considered as a *Bucania* or better as a *Porcellia* is quite irrelevant; I wish only to draw the attention of palæontologists to the typical similarity between these forms and the radially folded *Bellerophonts* of more recent formations, as the possibility cannot be denied, that the origin of the latter should be traced from the former.

Among the carboniferous *Bucania* there are two species with which the present form must be more accurately compared; these are *Buc. percarinata*, Conrad, and *Buc. montfortiana*, Norw. & Pratt. The former species is easily to be distinguished from *Buc. ornatissima*, W., by the three nodose carinæ which it bears on the peripheral part; as, however, in the present species also a certain tendency prevails to develope nodose swellings on the slit-band, where the radial folds cross over it, a rather close affinity between the two species cannot be denied. Besides the three carinæ no spiral sculpture seems to exist in *Buc. percarinata*.

The second species mentioned above, *Buc. montfortiana*, seems to be allied to *Buc. ornatissima* even more closely than the species described by Conrad, but a deep sulcus on the peripheral part in which the slightly raised narrow slit-band is situated and a very much expanded mouth in *Buc. montfortiana* make also here a distinction easy.

Nevertheless the similarity between *Buc. ornatissima* and the two American species is of interest. Very likely the Indian shell must be considered as a vicarious form, replacing the two American species in similar beds in India. Both the American shells belong to the fauna of the upper coal-measures.

Genus: MOGULIA, Waagen, n. gen.

It is with great doubt that I introduce this new genus. Only the analogiés to the genus *Forskalia* in the *Pleurotomaridæ* exhibited by the shells belonging to the new genus induce me to distinguish it.

The animals belonging to this genus possessed a thick heavy shell of a more or less globular general form. The whorls envelope each other entirely, and thus the umbilical region is occupied by a solid columella, every trace of an umbilicus being

absent. The sculpture of the shell consists only of broad squamose striæ of growth, without a trace of a spiral striation. The aperture is broad, more or less depressed, outer lip thin, inner lip strongly callous, with thick callous expansions on both sides, which cause a considerable thickening of the columella. The outer lip possesses in the middle a shallow angular emargination, the situation of which is easily traceable on the peripheral part of the whole shell by the course of the striæ of growth. By the great shallowness of the emargination, it becomes impossible that a proper slit-band should be formed, but each zone added to the size of the shell remains distinct for its whole extension, without touching the preceding one anywhere.

Thus the most characteristic features whereby to distinguish this genus from *Bellerophon*, with which it otherwise most nearly agrees, consist in the very shallow emargination, and in consequence of this in the absence of a proper slit-band.

Although the appearance of the single species known to me is so very characteristic, it may, on the other hand, be doubtful whether the distinctive characters are sufficiently important to warrant a generic distinction from *Bellerophon*. But since the same difficulties occur also between *Forskalia* and *Pleurotomaria*, in which genera the chief distinction (in fossil species at least) consists in the shallower emargination of the outer lip in *Forskalia*, and since the shells in reality seem to be so far distinct that *Forskalia* has been placed by H. and A. Adams in a quite distinct family, so also in the case of *Mogulia* a generic distinction from *Bellerophon* may be admissible, though the propriety of its foundation on a single species might be questioned.

I have decided on introducing the new genus on account of the very characteristic form of the single species it as yet comprises, and in the hope that a proper distinction of it might lead in the future to the discovery of further species belonging to it.

I have named this genus in honor of a native servant, who, with great cleverness, collected in the Salt-range a great many fossils for myself and Dr. Warth.

1. Mogulia regularis, Waagen, n. sp. Pl. XIII, fig. 4.

The general form of the shell is globose, with depressed inflated whorls, which envelope each other entirely, so that no trace of an umbilicus remains open.

The most characteristic feature of the species consists in the surface sculpture of the shell. This is composed of very regular zones, isolated from each other by rather deep furrows, which commence at the slight impression on the top of the columella and pass in a low arch directed backwards over the sides of the whorls, forming a shallow angle of about 115° on the peripheral part. The elevated zones as well as the furrows pass without interruption over the latter part of the shell. All the angular parts of the zones and furrows are situated one behind the other in one line, but nevertheless they form no slit-band, like in the species of the genus

Bellerophon, but only a disjoined series of angular costæ. On the elevated zones as well as in the furrows very fine striæ of growth seem to be present, which follow exactly the direction of the general sculpture.

The shell is rather thick and heavy, exactly as is also generally the case in the species of the genus *Bellerophon*.

The mouth is depressed reniform, the outer lip being tolerably thin, the inner one considerably thickened and callous, chiefly in the columellar region, where a thick callosity closes the umbilicus, which exists in the cast. The lateral expansions of the aperture seem to be very moderate.

The dimensions of the only specimen are as follows:—

Diameter of the shell	16 mm.
Greatest breadth of the mouth	15 „
Breadth of the mouth at the base of the lateral expansions	9 „
Height of the aperture from the top of the preceding whorl	6 „
„ „ „ „ upper margin of the lateral callosity	9 „
„ „ „ „ lower „ „ „ „	12 „

Locality and geological position.—The only specimen of this species was collected by Mr. Wynne at Khund Ghât, in the upper division of the Productus-limestone.

Remarks.—There is no species known to me to which the form here described could be compared. *Bell. leveillanus*, Kon., resembles it a little in its general form, but it has a thin shell and no callosity at its mouth, and thus must certainly be considered as belonging to a quite different division in the family *Bellerophontidæ* than *Mogulia regularis*, W. It might be a species of the genus *Warthia*, which will be next described. Also *Bell. angulatus*, Orb., bears only a very distant similarity, as the presence of a keel and striæ of growth which are suddenly deflected near it, though they are similarly distant from each other as in *Mog. regularis*, refer D'Orbigny's species to the true genus *Bellerophon*.

Genus: WARTHIA, Waagen, n. gen.

There are a number of species of *Bellerophonts* known to exist in older formations which in most of their characters agree well with those forms considered as belonging to the genus *Bellerophon*, but which deviate in one important point from the true *Bellerophonts* in the absence of a distinct slit-band on the peripheral part of the shell.

Already D'Orbigny recognised the importance of this character; but he was of opinion that the shells so characterized had been united by Conrad under the name of *Cyrtolithes*, and therefore he transferred all the *Bellerophonts* in which no distinct slit-band was known to Conrad's genus. If we compare, however, Conrad's typical species, *Cyrtolithes ornatus* from the Hudson river group, as figured

by Hall, we must confess that *Cyrtolithes* is something very different from all the other *Bellerophonts*, and that it may even be questioned if this shell can at all belong to the family. Also the species quoted as the first by D'Orbigny (*Bell. bilobatus*, Sow.) differs widely from *Cyrtolithes ornatus;* but, on the other hand, it exhibits a series of characters which distinguish it widely from the species of the genus *Bellerophon*, and it may thus justly be considered as the type of a genus different from *Bellerophon*, though it may not be identical with *Cyrtolithes*.

I also should have liked to consider *Bell. bilobatus*, Sow., as the type of the new genus, if M'Coy had not registered an observation which does not agree with the characters I consider as essential in the genus. He states that in specimens of *Bell. bilobatus*, in which the shell is well preserved, a slit-band is observable on the peripheral part of the shell. Though from the form of the emargination in the outer lip of the aperture it already seems very improbable that a slit-band exists, yet I have not got materials to prove or disprove M'Coy's observation, as specimens of *Bell. bilobatus* with well preserved shell seem to be rather rare. Thus I am unable to introduce *Bell. bilobatus* as the type of my genus, but must consider as such one of the species described hereafter.

From the specimens at my disposal I am able to deduce the following characteristics of the genus:—Shell symmetrically enrolled in one plane, more or less globular, without umbilicus. Surface smooth, without a spiral striation, striæ of growth very indistinct. Shell of moderate thickness. Aperture simple, outer lip slightly thickened and sometimes very little contracted, with a more or less broad and deep rounded median insinuation, which does not form a slit-band in the course of growth of the shell; inner lip more strongly thickened or slightly callous; columella thick, solid, callous.

This genus differs very widely from *Bellerophon*, though most species belonging to it have hitherto been classed with the latter genus. It is not only the absence of a slit-band which marks the difference, but also the form of the aperture, in which the lateral expansions are absent; the inner lip, which is not largely spread out over the preceding whorl; and the outer lip, which is thickened and sometimes contracted instead of expanded; all bear characters which make a generic identification with *Bellerophon* impossible. On the whole, the relation of *Warthia* to *Bellerophon* is similar to that which exists between *Pleurotomaria* and *Platyschisma*. The name of *Warthia* is given to these shells in honour of Dr. H. Warth, Collector of Customs at Pind Dádun Khán, who has given me a great many beautiful specimens of fossils from the Salt-range strata.

Of other genera of the *Bellerophontidæ* only *Mogulia* can be compared, but this agrees much more nearly with *Bellerophon* than with the present genus, the only difference from *Bellerophon* consisting in the shallow emargination of the outer lip, and the absence of a proper slit-band. From *Warthia* it differs by the angular shape of the emargination in the outer lip, by this latter part being sharpened and

not thickened, and by the inner lip being largely spread over the preceding whorl and being strongly callous.

In the palæozoic deposits of the Salt-range there have been found three species of *Warthia*, which I shall call *W. polita*, *W. brevisinuata*, and *W. lata*. The first of these belongs to the upper division of the Productus-limestone, the second to the lower division, and the last to the middle division of the same formation.

About the developmental connection of these species to geologically older forms complete darkness prevails; but even the shells in the Salt-range, though occurring in consecutive strata, are in no connection whatever to each other, a proof that each of them is only a sporadic species, a straggler from some geographical region where species of the genus must have been numerous. But where was this? In the future perhaps it will be possible to give an answer to this question. There have been described three species of *Bellerophon* from Australia, *Bell. undulatus*, Dan., *Bell. strictus*, Dan., and *Bell. micromphalus*, Morr. All three undoubtedly belong to the genus *Warthia*, though all three are specifically different from the Indian fossils. Also Australia does not seem to have been the proper centre of origin for the genus, but very likely somewhere in the space intervening between Australia and India.

1. Warthia polita, Waagen, n. sp. Pl. XV, fig. 7.

The general form of the shell is thick lenticular, the whorls not very strongly inflated, entirely enveloping each other, so as to leave no umbilicus open.

The surface of the shell is perfectly smooth, nearly polished, and no trace of any sculpture is observable. Even with the lens barely any trace of the striæ of growth can be detected. Also the peripheral part is perfectly smooth, and it is most certain that not a trace of a slit-band has ever been present.

The shell is rather thick and solid. The aperture is semilunar, widely open, but not expanded. The outer lip is thick, somewhat swollen, slightly sharpened from without and a little bent inwards. The emargination in the middle part of it is rather deep, broad, and well rounded. The inner lip is considerably thickened, but there exists no distinct callosity. The greatest thickening of the shell occurs at the columellar parts.

The dimensions of a specimen from Chidru are as follows:—

Diameter of the shell	8 mm.
Breadth of the shell at the aperture	6 „
Height of the aperture from the top of the preceding whorl	2·5 „
„ „ „ „ columella	3·5 „

The species seems not to grow much larger than the specimen of which measurements are given. The opening of the median insinuation of the outer lip is 38°.

Locality and geological position.—There are two specimens of this species preserved in the Salt-range collection, both of which were collected by myself at Chidru in the topmost beds of the Productus-limestone.

Remarks.—This little species, though deprived of every kind of ornamentation, is very characteristic in its general form, and will be easily recognised if found elsewhere. Nevertheless I know of no carboniferous fossil which could be compared to the present species. Of all the European *Bellerophonts* hitherto described, only *Bell. bilobatus*, Sow., which also is very likely a *Warthia*, bears a rather close resemblance to the Indian shell; it is, however, easily distinguishable by its deeper insinuation in the outer lip of the aperture and by the more rapidly increasing whorls. *Bell. bilobatus* is a silurian species. In devonian strata a similar fossil seems to occur, if one may trust Bigsby's indications, who, however, under the heading of Sowerby's species unites all the varieties of *Bell. trilobatus*, a species entirely different from *Bell. bilobatus* and belonging very likely to Meek's genus *Tropidodiscus*. Possibly *Bell. deslongchampsi*, Orb., represents the group of *Bell. bilobatus*, Sow., during the devonian period. During carboniferous times no species allied to *Bell. bilobatus* has been known up to the present, unless one should be inclined to consider *Bell. leveillanus*, Kon., as such. But this latter species on a first glance can be distinguished from *Bell. bilobatus* as well as from *Warth. polita* by the presence of a tolerably large umbilicus.

Of the Australian species of the genus *Warthia*, only *Warth. micromphalus*, Morris, can at all be compared to the present species, but it is immediately distinguishable by the presence of a kind of umbilicus.

2. Warthia brevisinuata, Waagen, n. sp. Pl. XV, fig. 6.

The general form of the shell is globular, as broad as it is high. The whorls are strongly inflated, somewhat depressed, and entirely enveloping each other, so as to close the umbilicus entirely, only a very slight impression remaining in the place of the umbilicus. They are rapidly increasing in breadth, not so in height. Very possibly, owing to some deformity, the specimen figured deviates from the regular spiral at a short distance from the aperture.

The surface of the shell is smooth and devoid of any kind of sculpture, but it does not appear polished as in the preceding species. With the lens very distinct striæ of growth are observable, passing in a tolerably straight line from the umbilical region to the peripheral part of the shell, where they form a very shallow and broad reversed arch. These striæ of growth are not all equal in strength, but some are more strongly marked, others less so. Those of the stronger sort occur at rather regular tolerably distant intervals. But even these stronger striæ of growth are barely visible without the lens.

The shell is not very thick, and also not much thickened in the umbilical

region. The general form of the aperture is depressed reniform, the outer lip tolerably thick, sharpened from without and slightly bent inward. It bears a very broad but very shallow insinuation in the middle, which forms a low and broad arch. The inner lip is but very little thickened, not callous, and spreads only a very short distance over the peripheral part of the preceding whorl, barely extending in front of the aperture. The lateral or columellar parts of the inner lip are also but very little thickened.

The measurements of a specimen from the Nila Wán are as follows :—

Diameter of the shell	13 mm.
Breadth of the shell at the aperture	14 „
„ „ „ base of the aperture	8 „
Height of the aperture from the top of the preceding whorl . . .	5 „
„ „ „ columellar parts	10 „

The species seems not to attain larger dimensions. The opening of the insinuation in the outer lip of the aperture is about 95°.

Locality and geological position.—There have been collected two specimens of this species by myself in the Nila Wán ravine, in a dark strongly micaceous sandstone, among the very lowest fossiliferous beds of the Productus-limestone formation.

Remarks.—Like the preceding species so also can this one only be compared to a silurian shell, which has been described by Portlock under the name of *Bell. gibbus*. As in the present species its whorls are very much inflated, broader than high, the shell is smooth, only covered by irregular striæ of growth. The difference from the Salt-range species seems to consist chiefly in a much shallower insinuation of the outer lip, and in whorls which are less rapidly increasing in breadth.

From *Warth. polita* the present species is very easily distinguishable by the much more inflated general form of the shell and the much broader insinuation in the outer lip.

There exists no connecting link whatever between *Warth. brevisinuata*, W., and *(Bell.) Warthia gibba*, Portl.

3. Warthia lata, Waagen, n. sp. Pl. XIV, fig. 8.

The general form of the shell is transversely fusiform, much broader than it is high. The whorls are very depressed, entirely enveloping each other, so as to leave no umbilicus open. The latter seems to be closed by a tolerably thick callosity, but a shallow groove remains, where its place ought to be.

The surface of the shell is not very well preserved, but seems to have been smooth, not a trace of any spiral sculpture, of any striæ of growth, or of any kind of a slit-band being observable.

Also the aperture is not well preserved; its general outline is elongated reni-

form, four times as broad as it is high. The outer lip seems to have been not very thick, the shape and deepness of the median insinuation in it is, however, not recognisable. The inner lip is strongly thickened and callous, the callosity extending nearly halfway down the anterior peripheral part of the preceding whorl. The columellar or umbilical region seems to be most thickened where a thick callosity fills up the rather large umbilicus of the internal cast.

The shell is tolerably thin, except in the umbilical region.

The dimensions of the only existing specimen are as follows:—

Diameter of the shell	22 mm.
Greatest breadth of the shell at the aperture	29 „
Breadth of the preceding whorl at the aperture	22 „
Height of the aperture from the top of the preceding whorl	7 „
„ „ „ from the lateral callosity	15 „

Locality and geological position.—The only specimen of this species was found by myself at Katta, in a greenish-grey sandy marl, in the lower region of the middle division of the Productus-limestone (bed No. 13 of the section in my note book).

Remarks.—The position of this shell in the genus *Warthia* is not quite certain; but the total absence of any slit-band on the peripheral part of the shell, together with the other characters, makes it highly probable that it belongs to that genus. Certainty on this point will only be attained when a specimen with perfectly preserved aperture will have been found.

Nevertheless, I think it worth while to describe the species, as the exceedingly broad and depressed whorls of which the shell is composed, are so very peculiar, that, though the characters of the mouth be not preserved, yet the species will always be easily recognised.

There is no species known to me to which the present species could be compared; may *Bell.* (*Euphemus*) *orbicularis*, McCoy, be something like it?

Genus: EUPHEMUS, McCoy.

Already in the description of the genus *Bucania*, Hall, I have mentioned that, on the whole, the genus *Euphemus*, McCoy, ought to be considered identical with Hall's genus.

The characteristic of the genus given by McCoy is very short, and runs thus: "Globose, involute, monothalamous; surface spirally striated; no dorsal band." The arrangement of the species quoted under the heading *Euphemus* is very peculiar, and barely adapted to lead to a proper understanding of what ought to be considered as typical species. The first species quoted is only with a query put into the genus; the second species is figured. This is a minute shell with a cancellated sculpture and rapidly increasing whorls. By the smallness of the shell the existence of a slit-band might easily have escaped notice, and then there would exist no

difference between this shell and *Bucania;* the course of the striæ of growth is, moreover, highly suggestive of the existence of a slit-band. The third species is described from a cast, and is said to have had a thin and smooth shell. It is only the last species which seems to exhibit in a prominent manner all the characters indicated in the diagnosis of the genus, and thus I may be justified in considering the last species as the typical one. This last species is *Euphemus urii*, Flem., sp., a well known and most characteristic shell of the carboniferous formation.

Thus the characters which have been indicated for the genus by McCoy might stand as well, or even with greater correctness, if we exclude all the other species from the genus and retain only *E. urii* in it. Since the description of this latter species a number of similar forms have been detected; and also in the Salt-range, forms allied to *E. urii* are not at all rare. From all these species it will now be possible to give a more detailed characteristic than that drawn up by McCoy.

We may thus define the genus *Euphemus* in the following manner:—

The general form of the shell is more or less globular or lenticular, the whorls are rounded, and generally there is no umbilicus present. The shell is thick and heavy and covered by more or less numerous spiral folds, which, however, if the specimen be perfect, never reach up to the outer lip of the aperture, but leave a more or less long space of the shell perfectly smooth. The aperture is often contracted, never expanded. The outer lip is sometimes thickened, always bilobed, with a narrow, and generally not very deep insinuation in the middle, which does not cause the formation of a quite distinct slit-band, though slight indications of such might be traced for a short distance from the mouth. The inner lip is callous chiefly in its lateral or columellar parts.

The most remarkable feature among the characters indicated above are the spiral folds which occur in all the species belonging to the genus. Their number is very variable, from 38 down to 4, and the most remarkable thing is, that they never reach the outer lip of the aperture. In the different species occurring in the Salt-range they always stop just within the mouth, and leave the whole last whorl perfectly smooth. If the last whorl is broken off, these folds are not always firmly adhering, but sometimes fall off rather easily, and in examining a larger number of specimens one soon becomes convinced that the folds do not belong so much to the shell, properly speaking, but rather to the callosity of the inner lip deposited on the preceding whorl. This observation has also been made on the true *Bell. urii*, Flem., by Mons. de Koninck. The observation of the thinness of the shell, as stated by Portlock and D'Orbigny, very likely has taken its origin from the circumstance that the plaited callosity bearing the spiral folds has been taken by those authors for the entire shell. On the contrary, the genus *Euphemus* is among all the *Bellerophonts* the group which has, at least in some species, the thickest and heaviest shell.

Thus the spiral ridges of *Euph. urii* and its allies must be taken as columellar folds, and this circumstance seems to me of deciding influence on the solution of the

question of what nature the animals may have been which once inhabited the shells called *Bellerophonts*. There has never been observed a columellar fold in any Cephalopod, whilst this peculiarity of structure is of very general occurrence in the Gasteropods, and thus there is the greatest probability that also the *Bellerophonts* were Gasteropods.

The extension of these columellar folds requires yet a special notice, as different species show very different characters in this respect. In *E. urii* the folds project far in front of the mouth, so as to cover half of the last whorl. Similarly in *E. carbonarius*, Cox, but in this species some short elevated lines appear in the columellar region of the shell. From all this it appears that in *E. urii* and the other species with far-projecting columellar folds the greater part of the shell must have been covered by lobes of the mantle, which deposited in *E. carbonarius*, Cox, those irregular striæ in the columellar region of the shell.

In most of the Salt-range species, on the contrary, the greater part of the shell must have been free, as the columellar folds are here restricted to the portion of the shell within the mouth.

If we look through all the species of *Euphemus* described up to the present, we will easily find out that they may be distributed in two groups, each of which comprises several species. The first of these is the group of *Euph. urii*. This group is characterized by very numerous columellar folds, which always project more or less widely in front of the mouth. This group seems to commence already in silurian strata, but of the older forms very little is known. From the mountain-limestone upward there seem to be several species of which only few have been distinguished up to the present. These are *Euph. urii*, *E. carbonarius*. Cox, and a species from the Salt-range which I shall call *E. lenticularis*, W. It seems to be likely that these species are in developmental connection with each other, and if this is the case, there seems to prevail a tendency among them to diminish the number of columellar folds. I should not like, however, to express any positive opinion on this point.

The second group seems to commence only in carboniferous times, and the oldest species known to me is *E. orbignyanus*, Portl. The group is characterized by much less numerous columellar folds, which do not project far in front of the mouth of the shell. There are three species of this group in the Salt-range, in which the number of columellar folds is between ten and four. In *Euph. orbignyanus* this number is already twelve, and from this it appears that also in this group the number of columellar folds decreases with the progressing age of the developmental series. The Salt-range species have received the names of *E. indicus*, W., *E. apertus*, W., and *E. lævis*, W. Also *Euph. nodocarinatus*, Hall, sp., from the coal-measures of Iowa belongs to this group.

a. Group of *EUPHEMUS ORBIGNYANUS*, Portl., sp.

1.—Euphemus indicus, *Waagen*, n. sp. Pl. XV, figs. 1, 2.

The general form of the shell is globose, about as high as it is broad, but changes very much according to age. The whorls are depressed, entirely enveloping each other, so as to leave not a trace of an umbilicus remaining.

In all stages of growth two parts of the shell must be distinguished, the enrolled part, on which the columellar folds are deposited, and the last whorl, which is devoid of these folds.

The enrolled part of the shell has always very much depressed whorls, with a broadly rounded peripheral part on which the columellar folds are situated at rather irregular intervals. There are six or eight such folds present, so that the middle of the peripheral part of the shell is always occupied by a furrow, which separates the two median folds. The folds are acute and very narrow; the furrows between are broad and flat. The median furrow is generally somewhat narrower than those on both sides of it. On each side towards the umbilical region the folds decrease in height and the furrows in breadth; the thickly callous part of the shell, representing the columella and covering the umbilical region, is entirely devoid of the spiral plication. The plication is, however, subject to great variation, and often is more or less unsymmetrical, the furrows between the folds being narrower on one side of the median furrow than on the other.

The form of the last volution is somewhat different at different stages of growth. Where the columellar plication terminates, the surface of the whorl becomes quite smooth, only that on the inner whorls where the median furrow is situated, a very flat excavation can be observed on the outer whorl, limited on both sides by broad low ridges. At a diameter of the shell from 10 to 15 mm. the peripheral part of the shell is very regularly arched, the median impression is very shallow, and the ridges on both sides of it very low. The whole last whorl, up to the mouth of the shell, shows the same characters. On the outer lip of the aperture a tolerably deep narrow rounded emargination is present, corresponding to the median impression, limited on both sides by the low rounded ridges. It is thus evident that the impression replaces the slit-band of the other *Bellerophonts*, but no striæ of growth can be observed on it. Also on the other parts of the last volution are no striæ of growth observable. Only one of the great many specimens of this species possessed a distinct slit-band in the depression between the obtuse median ridges, shut in on both sides by very thin thread-like ribs. But this slit-band seems to be produced only by a peculiar kind of weathering.

As the growth of the shell progresses, the median part of the peripheral region becomes more and more elevated, the ridges get higher, and the median impression deeper, and on both sides of the crest, which is thus formed, a flat or

excavated zone extends; the lateral parts of the last volution, chiefly near the aperture in full-grown specimens, are again much swollen and inflated.

Most remarkable is the aperture. It is always more or less contracted, and even in young specimens such a contraction can be observed, though in a less degree than in full-grown ones. By this contraction the general form of the aperture becomes that of a more or less narrow curved slit. The outer lip is bilobed, the lobes thickened and bent inside, with a sharp angular point on the outer edge, and well rounded off towards the median insinuation. The inner lip is very strongly thickened and showing just within the aperture the termination of the six or eight columellar folds. The strongest callous part of the whole shell is that situated on the umbilical region, replacing the columella of other gasteropods.

The casts of this species are very peculiar. They consist of several smooth very depressed whorls, rather far distant from each other and leaving open in the middle a deep and rather wide umbilicus, which occupies about the third part of the whole diameter of the cast.

The dimensions of four specimens, Nos. I, III, and IV from Khund Ghât, and No. II from Káfirkot, are as follows:—

	I.	II.	III.	IV.
	mm.	mm.	mm.	mm.
Diameter of the shell	14	17	21	23
Breadth of the shell at the aperture . . .	14	18	20	23
Height of the aperture from the top of the preceding whorl	4	4·5	5	5·5

Other measurements are very difficult to give on account of the irregularity of form of this species. In all the four specimens the entire aperture is preserved. The size of specimen No. IV seems the largest the species can attain.

Locality and geological position.—This species is one of the commonest in the upper division of the Productus-limestone. It begins already in the middle division of the same formation, but is rather rare there, and in the lower division of the formation it seems to be entirely absent. It has been collected in the upper division of the Productus-limestone by myself at Katwáhi (3 specimens), at the village of Khura (7 specimens), west of that village (7 specimens), at Jabi in the Cephalopoda-bed (1 specimen), at Kufri (4 specimens), at Nanga (1 specimen), at Chidru (2 specimens), and trans-Indus at Káfirkot (9 specimens). By Mr. Wynne it has been found at Katwáhi (7 specimens), and at Khund Ghât (40 specimens), and trans-Indus at Bilot in a very remarkable yellow crinoidal limestone (3 specimens), and at Kiri (1 specimen).

In the middle division of the Productus-limestone, one specimen was collected by Dr. Oldham at Músakhel.

Remarks.—This species is highly characteristic in its general form, and may serve as an excellent "Leitmuschel," as it is very common, and nearly entirely restricted to the upper division of the Productus-limestone. There is no species in Europe with which the present one could be compared, only in the American coal-measures a somewhat similar shell has been found, and described by J. Hall under the name of *Bell. nodocarinatus*. There are, however, several points of difference which make a distinction of the two species very easy. The columellar folds, which are in *E. nodocarinatus* also eight in number, project rather far in front of the aperture, and the crest near the aperture is nodose, whilst it is smooth in our species. Thus the American shell might be considered as a vicarious form, as has been the case already with several species described by me from the Salt-range, but it is certainly specifically distinct.

2.—Euphemus apertus, Waagen, n. sp. Pl. XV, fig. 3.

Though only one specimen of this species has been found up to the present, yet this seems to be sufficiently different from specimens of the preceding species to allow of its distinction as a separate species.

The general form of the shell is globose, very little higher than broad. The whorls are inflated, broad, depressed, and entirely enveloping each other, so as to leave not a trace of an umbilicus open. In an entirely preserved state the last whorl is smooth, with two sharp carinæ in the middle of the peripheral part of the shell. On each side of these carinæ there spreads a tolerably flat sloping zone united in a rather sudden curve with the lateral parts of the whorl, which in a narrow arch bend into the aperture of the shell. Already at a quarter of a whorl from the aperture the carinæ are concealed by the callosity which forms part of the inner lip of the aperture. Like in other species of the genus, the callosity is provided with spiral folds, of which I count in this case nine, and in consequence there is a median fold in this species, instead of the median groove in the preceding one. The folds are low and rounded on the top, but very narrow and separated by broad flat furrows. They project for a quarter of a whorl from the aperture.

The aperture is depressed reniform with a thin and sharp bilobed external lip, which is not bent inward. It bears in the middle a narrow and deep rounded emargination, which is situated between the two sharp carinæ mentioned above. Each lobe of the outer lip is rounded off on the external corner, and passes gradually into the callosity which covers the umbilical region. The inner lip with its strong callosity and columellar folds considerably contributes towards the thickening of the shell at the aperture.

The measurements of the single existing specimen are as follows:—

Diameter of the shell	13 mm.
Breadth of the shell at the aperture	12 „
Height of the aperture from the top of the preceding whorl . . .	4 „

Locality and geological position.—The only specimen of this species which has been found up to the present was collected by myself in topmost beds of the Productus-limestone at Virgal.

Remarks.—This species is very nearly allied to the preceding one, but nevertheless it is not very difficult to distinguish it from specimens of an equal size of *E. indicus*, W. The two sharp carinæ on the peripheral part of the shell, the median columellar fold at the aperture, and the great space covered by the callosity of the inner lip with its folds, are all characters that do not occur in *E. indicus*, and serve well to distinguish the present species from it.

Among European and American fossils there is no species to which the present one could be more specially compared.

3. Euphemus lævis, Waagen, n. sp. Pl. XV, fig. 4.

The general form of this little shell is globose, very little broader than high. The whorls are very much depressed, entirely enveloping each other, so that no umbilicus is left open. In specimens with the last whorl preserved, the surface of the shell is entirely smooth. In the middle of the peripheral part of the shell there is a very shallow spiral impression, which is limited on both sides by low, narrow elevated lines; these resemble perfectly the columellar folds, and it appears as if two of them accompanied the median impression up to the mouth of the shell. Of columellar folds there are not more than four, of which the two middle ones unite with the elevated lines on both sides of the median impression on the peripheral part of the last whorl. The outer two are very short and show just within the aperture.

The aperture is broad and very depressed, the outer lip very sharp and thin, slightly bent inside with a short, broad, rounded emargination in the middle. The two outer corners of the outer lip are sharply pointed, and unite at about right angles with the rather thick callosity which covers the umbilical region. The inner lip seems to be not very strongly callous.

The measurements of two specimens, No. I from Chidru, No. II from Kufri, are as follows:—

	I.	II.
Diameter of the shell	8 mm.	9·5 mm.
Breadth of the shell at the aperture	9 „	9·5 „
Height of the aperture from the top of the preceding whorl	2 „	3 „

The diameter of specimen No. II seems to be the largest the species can attain.

Locality and geological position.—There are altogether five specimens of this little species in the Salt-range collection which were all found by myself in the upper division of the Productus-limestone; three of these were collected at Chidru in the topmost beds of the Productus-limestone, one at Kufri in the section there, and one at Katwáhi.

Remarks.—This species resembles to a certain extent *E. carbonarius*, Cox, but the number of columellar folds is entirely different. From equally sized specimens of *E. indicus* it differs by the elevated lines which accompany the median impression and by the number of columellar folds, which is six or eight in *E. indicus* and only four in *E. lævis*. The same differences distinguish it from *E. apertus*, W.

Thus the little shell seems to constitute a well distinguishable new species.

b. Group of *EUPHEMUS URII*, Flem. sp.

4. Euphemus lenticularis, Waagen, n. sp. Pl. XIV, fig. 9.

This is a very small and very rare species, of which only one specimen has been found up to the present.

The general form of the shell is lenticular, with a narrowly rounded periphery. The whorls are low, laterally compressed, and envelope each other entirely so as to leave no umbilicus open.

The only specimen I have for description is not entire, part of the last volution having been broken away. As it is, the shell seems to consist of two differently ornamented parts, each of which takes up about half of a whorl. The outer half whorl, towards the aperture, is entirely smooth, not even striæ of growth or any kind of a slit-band being observable on it; the inner half-whorl, removed from the aperture, is covered by closely arranged fine spiral striæ, which disappear within the broken mouth of the shell, continuing also on the covered inner volutions. Their number is about 22. They are narrow, rounded on the top and separated from each other by flat furrows, which are not much broader than the elevated striæ. Striæ of growth which would cross over the spiral striation and cause a somewhat cancellated appearance of the surface of the shell are not observable; also any distinct slit-band is entirely wanting.

The aperture has been quite broken away, and thus it cannot be observed if it was bilobed and somewhat contracted, and of what shape and size the median emargination of the outer lip may have been. The transverse section of the whorls is ogival-semilunar. Neither the peripheral part of the inner volutions nor the umbilical region of the shell is strongly thickened by callosities. Callosities are present, but very moderate in thickness.

The measurements of the single existing specimen are as follows:—

Diameter of the shell	7 mm.
Greatest breadth of the shell	5 „
Height of the aperture from the top of the preceding whorl	2 „
„ „ „ from the umbilical region	4·5 „

Locality and geological position.—The only specimen of this species contained in the Salt-range collection was found by myself at Amb, in a dark coaly

sandstone, at the very base of the fossiliferous beds of the Productus-limestone formation.

Remarks.—This little shell has been for a long time a great puzzle to me, as the general appearance of it is nearly absolutely identical with that of a striated *Goniatite*. But though I searched carefully for the air-chambers, yet I was absolutely unable to detect them. On the other hand, the stoppage of the spiral striation half way on the last whorl, combined with the apparent absence of air-chambers, was suggestive of this little shell being a *Bellerophont*. Thus I have decided on placing it in this family.

Among all the *Bellerophonts* the species can only be compared in general to those shells which are more or less nearly allied to *Euph. urii*, Flem., and in particular chiefly to *Euph. carbonarius*, Cox. Like this species, *Euph. lenticularis*, W., possesses about 22 revolving striæ or columellar folds. The other characters, however, cannot be compared, as the specimen of the Indian species is not sufficiently well preserved to do so. That *Euph. carbonarius* is, however, not identical with *Euph. lenticularis* appears already from the general form of the shell, which is globose in the American and lenticular in the Indian species. Both forms might, on the whole, very well be considered as vicarious species. *Euph. carbonarius* is a species from the upper coal-measures, or the permo-carbon formation of the American authors.

Genus STACHELLA, Waagen, n. gen.

Up to very recent times barely any unsymmetrical *Bellerophont* has been known, though the existence of such forms was already indicated by the genus *Bellerophina*, Orb., which in its unsymmetrical structure resembles somewhat the unsymmetrical *Bellerophonts*, but can easily be distinguished by the total absence of a slit-band.

Only through G. Stache's monograph of the fauna of the Bellerophon-limestone of the Alps a number of unsymmetrical forms have been made known; this author, however, did not then think it proper, relying only on the not very extensive materials at his disposal, to create a proper generic designation for these shells, though he admitted the probability of their constituting a distinct generic group. The variety of forms described by him is rather large, and he was able to distinguish not less than seven species. All of these, as it seems to me, cannot properly be considered as belonging to one and the same group; two (*Bell. sextensis* and *Bell. guembeli*), which by the very strange form of their volutions and of their apertures deviate more or less altogether from the type of other *Bellerophonts*, will have to be excluded, if we wish to unite a certain number of forms under a new generic designation. The remaining five species form a very good natural group, to which I am now able to add two new species.

The question is, whether the unsymmetrical development has not to be considered as a kind of deformity caused by some injury the animal has received when

young. The possibility of such a cause cannot be denied, but the geological occurrence of the unsymmetrical forms is so peculiar that the existence of some deeper cause must be accepted as more probable. In older formations unsymmetrical specimens of *Bellerophonts* are of very rare occurrence; when such are found, it is never difficult to assign the specimen to some symmetrical species, or to detect the mode of injury the specimen had received. The case is different with the unsymmetrical *Bellerophonts* here under consideration. All the different forms described by Stache constitute species which are not different from symmetrical ones solely by their unsymmetrical development, but which would, even if they were symmetrical, have to be considered as distinct species. This, together with their sudden appearance in great numbers in the uppermost palæozoic deposits, makes it highly probable that the unsymmetrical development of certain forms was not only caused by the illness of the animal in certain specimens, but that the reason of it was some difference in structure, which caused all the specimens of one species as well as of a whole group of species to be unsymmetrically developed; and thus it may well be justified to consider these unsymmetrical forms as constituting a separate genus.

The materials I have of this genus are not very extensive or very well preserved; chiefly the aperture is in all the specimens more or less broken. From what can be observed the following characteristic of the genus may be deduced:—

Shell inflated, more or less globular, with unsymmetrical whorls, which make the shell appear as if not coiled in one plane. One side of the shell thus appears broader and may be considered as basal, the other is narrower and would then be apical. Considered in such a manner, one can distinguish between left and right-hand turned shells, and specimens of both descriptions occur sometimes in one and the same species. The shell is thick and heavy, and is ornamented by more or less frequent striæ of growth, which form a distinct slit-band on the peripheral part of the shell. This is, however, only very superficial and easily rubbed off if the shell is not very well preserved.

The aperture is very peculiar in its shape, angular on the basal and narrowly rounded on the apical side of the shell. The outer lip is thin and sharp with a median emargination, the inner lip is but slightly callous, and only on the apical side of the shell with a moderate lateral expansion. The apical side of the shell is sometimes provided with a small umbilicus, sometimes not.

The genus is represented in the palæozoic deposits of the Salt-range by two species, which I shall describe under the names of *Stachella bifrons*, W., and *St. semiaurita*, W. Both these species occur in the same strata and belong to the fauna of the upper division of the Productus-limestone. Each of the Salt-range forms seems to be more or less nearly related to a species of the Bellerophon-limestone of the Alps, and *St. bifrons* can be compared in particular with *St. pseudohelix* St. sp.; *St. semiaurita*, on the other hand, seems to be most similar to *St. janus*, St. sp. It is of high geological interest to point out these similarities, which may

very well indicate a developmental connection between the single species; c the one hand, because this might possibly furnish a clue towards the elucid tion of the question where the *Bellerophonts* of the Bellerophon-limestone ha migrated from to the alpine territories; on the other hand, because the geologic horizon of the Bellerophon-limestone has been fixed either as upper permian or the lower horizon of the Bunt-Sandstein. Species nearly related to the forms the Bellerophon-limestone might thus indicate for the Salt-range beds in whic they occur a rather high horizon in the palæozoic series.

1. Stachella bifrons, Waagen, n. sp. Plate XV, fig. 5.

The general form of the shell is globose with very strongly inflated whorl which leave no umbilicus open on the basal side of the shell, and but a very sma one on the apical side. The basal side is slightly impressed on the umbilical regio The whorls are well rounded everywhere, and also the umbilicus is not surrounde by any distinct edge, but the curve is not an equal one. The laterally most pr minent part of the whorls lies high up on the basal side of the shell, whilst it immediately above the umbilicus on the apical side.

The surface of the shell is very badly preserved in all the specimens at my di posal, and in none of them can either striæ of growth or a slit-band on the peripher part be observed.

The shell is not very thick, and even in the umbilical region it is not strongl thickened.

The aperture is unsymmetrically semilunar, angular on the basal and narrowl rounded on the apical side. The outer lip seems to have been thin and sharp, th emargination in the middle of it is not preserved in any of the specimens. It start from the impression on the umbilical region of the basal part of the shell in hyperbolical curve towards the front, is thickened and somewhat callous, but canno be traced in its further outline. The inner lip is but little callous, and contribute but little to the thickening of the peripheral part of the inner whorl. It unites wit the outer lip on the basal part of the shell in an obtuse angle and on the apica part in a narrow curve, thickening by a slight callosity the low wall which sur rounds the small but deep umbilicus.

The measurements of the largest specimen at my disposal are as follows:—

Diameter of the shell	27 mm.
„ of the umbilicus on the apical part of the shell . .	3 „
Greatest breadth at the aperture	23 „
Height of the aperture from the top of the preceding whorl	9 „
„ „ „ from its lower termination at the basal side	15 „
„ „ „ from the umbilical suture at the apical side	16 „

The greatest transverse diameter of the aperture lies not on a horizontal line, bu makes an angle of about 10° with that line.

Locality and geological position.—There are altogether three well determinable specimens of this species in the Salt-range collection, one of which was collected by Mr. Wynne at Khund Ghât in the upper division of the Productus-limestone, another was found by myself at the village of Khura in the same beds, and the third also by myself west of that village in the uppermost beds of the middle division of the Productus-limestone.

Remarks.—As I have already mentioned in the introduction to the genus, there exists a certain similarity between this species and *St. pseudohelix* of the Bellerophon-limestone of the Alps. The two species can, however, very easily be distinguished by the more compressed shape of the alpine shell. Of other species *Stach. mojsvari,* St., sp., might be compared, but this is on a first glance distinguishable by its less unsymmetrical form.

2. Stachella semiaurita, Waagen, n. sp. Plate XVII, figs. 1, 2.

The general form of this shell is inflated globose, with a somewhat prominent peripheral part, which is, however, not keeled, properly speaking. The appearance of different individuals is rather different, as left-hand and right-hand turned shells occur indiscriminately in this species.

The whorls are strongly inflated and entirely enveloping each other, so as to leave no umbilicus open, either on the basal or on the apical side of the shell. In the place of the umbilicus there is on both sides a rounded impression. On the apical side the outline of the whorls starts from the umbilical impression in a horizontal solid columella, which passes with a very narrow curve into the narrowly rounded lateral part, immediately succeeded by a broad flat sloping space reaching up to the obtusely angular median portion of the peripheral part of the shell. On the other side there is again a somewhat flat space, which is, however, less sloping, and passes into a tolerably broad vertical zone, slightly curved inside, joining the umbilical impression on the basal side of the shell.

The surface of the shell is ill preserved, and not a trace of striæ of growth can be detected; nevertheless faint remnants of a slit-band are yet observable on the peripheral part of the shell. This is approximately median, and is situated on the culminating obtusely angular part of the periphery. It consists of a very narrow furrow, which appears as if cut in with a knife, limited on both sides by very narrow, low, raised lines.

The shell is thick and heavy, and strongly callous in the umbilical region.

The aperture is unsymmetrically reniform or semilunar, narrowly rounded off on the apical side of the shell and broadly obtusely angular on the basal side. The most characteristic feature in the form of the aperture is the development of an ear-shaped expansion on the apical side of the shell. The outer lip is very thin and fragile, and not preserved in any of the specimens at my disposal. It is certain that it possessed an emargination in the middle, but the form of the latter can only

be guessed from the form of the slit-band, and judging from this, it must have been very narrow and very deep. The inner lip is not very strongly callous, only in the umbilical region a more strong callosity is developed. On the apical side of the shell a tolerably prominent callous expansion of the inner lip exists, which thickens the solid columella.

The measurements of two specimens are as follows:—

	I.	II.
Diameter of the shell	25 mm.	21 mm.
Greatest thickness of the shell	22 „	20 „
Height of the aperture from the top of the preceding whorl .	8 „	8 „
„ „ „ from the lower termination at the basal side	15 „	13 „
„ „ „ from the lower termination at the apical side	14 „	12 „

The greatest breadth of the aperture lies not on a horizontal line, but making an angle of 12° with it.

Locality and geological position.—There are altogether three specimens of this species preserved in the Salt-range collection, which all three were found by Mr. Wynne in the upper division of the Productus-limestone at Khund Ghât.

Remarks.—This species is in its general form not very much different from the preceding one, with which it occurs in one and the same bed, but it can easily be distinguished by the absence of an umbilicus on the apical side of the shell, by the more elevated peripheral part, and by the stronger callosity of the inner lip of the aperture. Among the species described by Stache is chiefly *Stachella janus*, St., sp., which seems to bear a certain resemblance to the present species. It is difficult, no doubt, to compare a cast and a specimen with the shell preserved, but it is highly probable that the cast of *St. semiaurita* W., will prove as largely umbilicated as that of *St. janus*. The slit-band and the peculiar flattening of the zones laterally adjoining it are very similar in both species, only the Alpine species seems to have been less inflated than the Indian one. Of the other species of unsymmetrical *Bellerophonts* none can be compared to *St. semiaurita* W.

Order: CONULARIDA.

Family: *THECIDÆ.*

Genus: HYOLITHES, Eichwald.

On a very recent occasion Prof. M. Neumayr has decidedly expressed the opinion that the shells referable to the genus *Hyolithes* should not be considered as belonging to the Pteropods, but that they should probably be better placed somewhere near the *Capulidæ*.

It cannot be denied that there exists no direct proof, as Prof. Neumayr very rightly remarks, for the supposition that these shells are Pteropods, but by suggesting for them a place near the *Capulidæ*, they would be transferred to the order of the

Prosobranchiata, with which the structure of the shell seems to be but very little in accordance. Shells like *Rhombifera*, Barrande, *Pterotheca*, Salt., or even *Conularia*, are so utterly diverse from anything known to exist in the *Prosobranchiata*, that I think it as little advisable to unite them with this order of Mollusks, as to refer them unreservedly to the *Pteropoda*.

The circumstance which most strongly speaks against these shells being *Pteropoda* is their occurrence in more or less littoral deposits in company with other littoral shells. So much is certain from this observation, that, if these fossils belong to the *Pteropoda*, their habits of life must have been different from those now prevailing among Pteropods, and though they may have been floating animals, yet they certainly were not pelagic ones.

On the other hand, it cannot be denied that the greatest analogies of these shells lie with the *Pteropoda:* only among the shells of Pteropods do we find similarly bizarre forms; and former writers were certainly justified in comparing the fossils here under consideration with the shells of Pteropods. Yet this comparison must not be accepted as establishing an undoubted fact.

The real nature of these fossils very likely will never be known. It is barely likely that we shall ever detect the lingual teeth of these animals, or that we shall learn whether the animals possessed fin-like appendages and of what nature these were, and thus a direct proof for their being Pteropods will hardly ever be available.

Thus in order not to assert things which we do not know, it will be most advisable not to consider these shells unreservedly as Pteropods, but to create a proper order for the reception of them which might receive, from the most conspicuous genus, the name of *Conularida*, and to place this order next to the *Pteropoda* in order to express the analogies the fossil shells exhibit to the shells of the recent *Pteropoda*. The order would for the present contain three families—

I.—Fam. *Conulariidæ*.
II.—Fam. *Thecidæ*.
III.—Fam. *Tentaculitidæ*.

These families are composed entirely of fossil shells, and are almost exclusively of palæozoic distribution. Also this circumstance speaks in favour of a thorough distinction from the true *Pteropoda*, as a large gulf in time exists between the fossil and the recent orders.

The genus *Hyolithes* is very easy to be recognised. The shells belonging to it are elongate, acute on one side and truncated on the other. Their section is more or less triangular, with rounded-off corners. The sculpture generally consists in parallel transverse striæ of growth; there are however also many species which possess longitudinal ridges. The shell is not always straight, but mostly its lower apex is curved. An operculum seems to be generally present.

The name *Hyolithes* has beyond doubt priority; though when first proposing the name, Eichwald gave a very insufficient diagnosis of the genus. But after

the name of *Hyolithes* has been accepted in Barrande's great work, its general acceptation in science must be advocated.

In the Salt-range two species occur which with some probability can be attributed to the genus *Hyolithes;* but the determination of which is not quite certain, as the specimens are compressed, and the triangular section cannot be observed.

The greatest number of species of *Hyolithes* has hitherto been detected in the silurian formation. In devonian as well as in carboniferous strata species of the genus are much more rare, and in permian times it appears only in more or less isolated species. But it does not stop here. In the trias of the Alps the genus has been detected; and most recently a species from the lowest Alpine lias has been described by Prof. Neumayr.

1. HYOLITHES ORIENTALIS, Waagen n. sp. Pl. VIII., fig. 3.

This very small species is very indifferently preserved; but nevertheless I think it worth mentioning, as the occurrence of species of *Hyolithes* is always more or less of interest.

The general form of the shell is straight, lanceolate, very gradually but not equally tapering, the outline not being formed by quite straight lines, obtusely pointed at the apex. The transverse section of the shell cannot well be observed, as all the specimens seem to be more or less deformed by pressure; but it seems that the section has been very compressedly triangular with strongly rounded-corners.
The surface of the shell is covered by numerous striæ of growth of very unequal strength, some of them being very strongly marked and forming a kind of rings, others very low and barely indicated.

The aperture seems to have been oblique, the margins of it being slightly produced on one side so as to form a very low broad lappet, and slightly cut out on the other.

The shell is smooth and shining and very thin.

The dimensions of two specimens, as far as they can be observed, are as follows:—

	I.	II.
Length of the shell	6 mm.	7 mm.
Breadth of the shell at the upper termination	1 „	1·5 „
Apical angle	3°	10°

There are no larger specimens of this species preserved in the Salt-range collection. The apical angle of different specimens seems to be very variable.

Locality and Geological Position.—This species has been observed up to the present at a single locality in the trans-Indus extension of the Salt-range, where several (7) specimens of it have been collected by Mr. Wynne at Saiduwáli. The bed from which they came is marked on the label "Sub-carboniferous shell below red beds." The rock is a black nodular shale with brown quartz grains.

Remarks.—In the compressed state in which all the specimens occur, the

species presents more or less of resemblance to several species of *Hyolithes*, yet by the great irregularity and strong prominence of its striæ of growth as well as by the variability of its apical angle, it possesses characters which make a distinction from other species not too difficult.

The great variability which prevails in the forms of the shell in the smooth *Hyolithes*, makes it unadvisable to express any opinion as to the relations in which the present species may stand to other forms. It exhibits a certain resemblance to *Hyolithes richteri* Gein., from the permian of Germany; also *H. lanceolatus* Morr. from Australia might be compared; but no stress can be laid on any such similarity.

A fact worthy of notice is the rather plentiful occurrence of this species at a single very limited locality.

2. Hyolithes (?) *sp. indet.* Plate VIII, fig. 4.

At the same locality and in the same beds with the preceding species, Mr. Wynne has collected a very small apical fragment of another shell which seems to indicate the existence of a second species of *Hyolithes* there.

The fragment is only 1·5 mm. long and immediately distinguishable from equally large specimens of *Hyolithes orientalis*, W., by its much larger apical angle, which is about 45°. The striæ of growth are also very irregular, the shell being at certain distances even slightly contracted, and thus it appears to have been more or less annulated. The fragment is, however, too small to express any definite opinion as to the ornamentation of the perfect shell.

Thus I shall not venture to give a separate name to this little fragment, though beyond doubt a separate species is indicated by it. On the other hand, the occurrence of such a second species seems to me sufficiently interesting to mention this little fragment, and to give a figure of it.

Genus (?) MACROTHECA, Waagen, n. gen.

It seems more or less hazardous to establish a new genus on a single not very well preserved specimen, as is the case with the present genus; but as it is, on the other hand, very awkward to drag along in the literature the figure of a highly interesting fossil without a name having been given, and since the fossil in question is a very strange one, I have decided on creating a new genus to receive it, though my definition of it may be rather vague.

Macrotheca is a conoid shell of gigantic dimensions, slowly tapering towards the apex, with an elliptic section, in which the longer diameter is only little greater than the shorter one. The ellipse is slightly flattened on one side, which might be the ventral one. There are no air-chambers present. The shape of the aperture cannot be observed. The shell is comparatively thin, and is without a surface sculpture.

I cannot place this strange shell anywhere else but in the family *Thecidæ*. It agrees in all the characters with the genus *Hyolithes*, except in its section not being triangular and in its gigantic size. In the genus *Hyolithes*, barely any species attains a greater length than 100 mm., whilst the shell here under consideration must have reached a length of about 320 mm.

On a first glance the shell shows a great resemblance to a brevicone *Orthoceras*, and for a long time I was in doubt whether the specimen figured on Plate XVI was not the body-chamber of such an *Orthoceras;* but there are some grave objections to such an interpretation of the fossil. In most of the brevicone *Orthoceratites*, the body-chamber is not very long; the fragment I have figured on Plate XVI represents about three-quarters of the entire length the shell once possessed. If this was a brevicone *Orthoceras*, a certain part of the shell must bear air-chambers. According to Barrande's tables (Syst. Sil., Vol. II, Plate IV, p. 40) the longest body-chamber that has ever been observed in an exceptional species of a brevicone *Orthoceras*, has four times the length of the diameter at its base. The fragment that I have figured has six times the length of the diameter at its base, and yet there is not a trace of any air-chamber or septum observable in the specimen, nor is the shell entire in the direction of the apertural margin. If it had been an *Orthoceras*, the chambered part of the shell could not have had more than 80 mm. in length, whilst the length of the body-chamber would not have been less than 250 mm. All this, combined with the transverse section of the shell which would be very exceptional for an *Orthoceras*, seems to forbid the reference of the specimen here under consideration to that genus.

If the shell is, however, not an *Orthoceras*, it can be placed only in the family *Thecidæ*.

Notwithstanding all these circumstances, the fossil will always remain a very obscure one, and therefore it is only with a query that I introduce a name for it. The very considerable bulk of the specimen did, however, not allow of its being left unnoticed.

1. Macrotheca wynnei, Waagen, n. sp. Plate XVI, fig. 4.

The general form of the shell is conoidal with an elliptic section and a slightly flattened ventral (?) side. The upper or apertural margin is not preserved, nor is the apical end.

The shell is not very thick in comparison to its size. Its thickness seems to have been equal originally throughout its whole extent, but it has apparently been worn down considerably by weathering in certain places. The surface is too ill-preserved to detect whether there were striæ of growth or not, and what direction these may have had.

If the shell be removed, a perfectly smooth cast appears on which not a trace of septa can be observed.

The whole gigantic cone is filled up by a hard yellow calcareous sandstone, swarming with badly preserved fossils, chiefly *Bellerophonts*.

The dimensions of the specimen are as follows:—

Probable length of the entire shell	330 mm.
Length of the preserved part	242 „
Transverse diameter at the upper end	124 „
Antero-posterior diameter at the upper end	112 „
Transverse diameter at the lower end	68 „
Antero-posterior diameter at the lower end	54 „
Apical angle	30°

Locality and geological position.—The only specimen of this species was collected by Mr. Wynne at Katwáhi, apparently in the upper division of the Productus-limestone, as the rock by which the specimen is filled swarms with species of the upper Productus-limestone.

Remarks.—The doubts as to the propriety of considering this species as the type of a proper genus have been expressed above. As to species, none exists with which the present one could be compared.

Order: PROSOPOCEPHALA.

Sub-Order: SCAPHOPODA.

Family: *DENTALIIDÆ.*

Sub-Family: ANTALINÆ.

Genus: ENTALIS, *Gray.*

It is very rare in palæozoic or even mesozoic strata to find specimens of Dentalium-like shells, which have their upper termination sufficiently well preserved to allow of an exact determination of the genus; and thus the geological range of the single generic groups is only very imperfectly known.

Thus also the genus *Entalis* has never been quoted in older formations.

The genus is characterized by a broad ventral insinuation at the posterior opening. The shell is thick and heavy, and is on its surface generally longitudinally striated. The only species of it in the Salt-range, *Entalis herculea*, Kon., sp., is, however, quite smooth.

As to the developmental connection of *Entalis herculea* to other forms of the *Dentaliidæ* nothing certain can be said, as even the generic position of most of the forms which might be compared is quite uncertain. *Dent. ingens*, Kon., which by its size seems to be allied, is probably a true *Antale*.

1. Entalis herculea, Koninck, sp. Plate XVI, figs. 1, 2, 3.

1863. *Dentalium herculeum*, Kon.. Quar. Journ. Geol. Soc., Lond., Vol. XIX, p. 8, Pl. IV, figs. 10—12.
1863. *Dentalium herculeum*, Kon.: Fossiles Paléoz. de l'Inde, p. 16, Pl. IV, figs. 10, 11, 12.

The general form of the shell is very elongated, very gradually tapering and only very slightly curved, the convex side being the ventral, the concave one the dorsal side. The transverse section of the shell is perfectly circular.

The surface of the shell is covered by closely arranged, but rather irregular striæ of growth, of which in adult specimens towards the aperture single ones are more strongly developed, so as to cause an indistinct annulation of the surface, composed of rather distant annulæ. The striæ of growth are not straightly transverse, but somewhat oblique, so as to reach further down on the ventral than on the dorsal side.

Like the striæ of growth, so is also the anterior aperture oblique, with a slightly produced margin on the ventral side. The apertural margin is thin, acute, sharpened from within.

The posterior aperture has thick rounded margins, and consists of a round opening on the dorsal side of the shell, and a tolerably long and broad slit reaching from the terminal opening a short way down the ventral side.

The posterior end of the shell appears thus to be cut off obliquely, the dorsal margin reaching about 6 mm. higher up than the ventral one.

The shell is very unequally thick at different distances from the anterior aperture. Whilst it is very thin, sharp and cutting at the aperture itself, it increased gradually in thickness towards the apex, so as to leave at last hardly any space free in the middle. Sometimes this thickening of the shell progresses very irregularly, and irregular longitudinal ridges of shelly matter are formed on the inner surface; such a specimen has been figured by M. de Koninck.

There has no complete specimen been found in the Salt-range, but fragments are extremely numerous; from these I endeavoured to compose an entire specimen, and it seems from this that the dimensions of a full-grown specimen of the species were as follows:—

| | | |

Locality and geological position.—This is one of the most common and most characteristic species of the upper division of the Productus-limestone. It is totally absent in the lower strata and exclusively restricted to the upper division. It is present nearly at all localities where these strata are exposed; but specimens from all localities are not preserved in the collection, as without exception only fragments occur, and only when these fragments attain a somewhat considerable size are they generally considered worth collecting. Thus the list of localities which follows here is only a small fraction of the number in which the species really occurs. The species was collected by myself at Chidru in the topmost beds of the upper division of the Productus-limestone (4 fragments), and in the lower beds of the same division (2 fragments), at the village of Khura (9 fragments), and west of that village (5 fragments), East of Katwáhi (1 fragment), at Nanga (1 fragment), at Kufri (1 fragment), and Trans-Indus Káfirkot (1 fragment). By M. Wynne it was collected at Khund Ghât (30 fragments).

Remarks.—Mons. de Koninck has compared this species to *Dent. ingens*, Kon., of the carboniferous limestone of Visé, but states that it is different from the Belgian species by its thicker shell and more regular conical form; to this may be added the much more slowly tapering shell, and the much less oblique position of the striæ of growth, in the present species. Besides this the posterior aperture seems to make the *Dentalium ingens* referable to the genus *Antale*, whilst the species here under consideration belongs to the genus *Entalis*. Of other species none can be compared to *Entalis herculea*, as none is of a similar size.

Genus ANTALE Aldrovand.

Most of the fossil species of *Dentalidæ* in older formations seem to belong to this genus, though only of a small number of them is the posterior aperture known.

The materials of this genus in the Salt-range collection are very miserable indeed; nevertheless I think it advisable to mention these small fragments, as by them the existence of two different species of *Antale* in the palæozoic strata of the Salt-range is indicated.

1. Antale (?) sp. indet.

Small fragments of an *Antale* more or less allied to *Ant. priscum*, Münst. sp., have been observed by me in the uppermost beds of the upper Productus-limestone at Virgal and at Chidru, but none of these fragments is sufficient to describe the species from, or to give a characteristic figure.

The shell seems to have been rather elongated and gradually tapering. It is thin and smooth, and only with the lens very fine striæ of growth can be detected, which are slightly oblique. On the whole it must have been more or less similar to *Ant. priscum* Münst. sp., though it seems to have been smaller than that species.

2. ANTALE (?). sp. indet.

Another species is much rarer than the preceding one, and is immediately distinguishable by its more considerable size. It seems to have attained the size of *Ant. ingens* Kon. sp., but is easily distinguishable from it by its thin and smooth shell.

The species seems to be restricted to the very lowest fossiliferous strata of the Productus-limestone, and has been observed by me in these beds in the Níla Wán where it occurs in company with *Warthia brevisinuata* W., in a dark strongly micaceous sandstone.

Class: PELECYPODA.

Order: PHOLADACEA.

Family: *GASTROCHÆNIDÆ.*

Sub-Family: *GASTROCHÆNINÆ.*

Genus: SPENGLERIA, Tryon.

As it has been already in many cases difficult to assign the species of *Gasteropoda* occurring in the Productus-limestone of the Salt-range to genera that have been described by former authors, and to point out in what relation those genera stand to the groups of forms now living, so is this even in a higher degree the case with the *Pelecypoda*, and, in many instances, the names used by me for the generic designation of the Salt-range species can only approximately indicate the real affinities of the shells for which they are used.

The causes from which these difficulties arise are manifold. In the first place must be mentioned the insufficiency of observation, as must occur with objects of which very often only one specimen is available for description, and preserved in a very hard rock, which can only with great trouble be removed. Another cause of difficulty exists in the actually 'mixed' characters exhibited by some shells; characters that are often widely distributed among different groups of recent *Pelecypoda*, whilst they are united in one shell in the fossil forms, so as frequently to cause most conflicting evidence as to the affinities of a certain form to one or other group of the existing system.

This latter circumstance however is in reality of no great consequence, as one stands on firm ground as soon as the characters of a shell can be well observed; and it is then only more or less a matter of scientific tact or taste, in what way such a question should be solved. Much worse is it when no complete observation is possible, whether on account of the scarcity of specimens or of their bad preservation. It may not be considered prudent to describe or identify a species from one specimen only; but in a collection of fossils brought together solely by travelling observers, and no considerable part of which has been the result of patient search, of months' or years' duration, at certain localities, as is very often the case with collections forming the materials for palæontological monographs in Europe, there must necessarily be a large number of species represented only by a single or by very few specimens.

Every one knows that it is not always possible, with only a single specimen, to make even the most important characters, such as the hinge, visible. From a purely palæontological point of view, it would then be more advisable to leave such specimens aside, and to describe only those species of which the greater part of the essential characters can be made out. But, in the present instance, the purpose of the work is not purely palæontological; the first thing required from it, is to give a full account of the organic remains contained in the strata of the Salt-range, as far as it has been possible to collect them on the part of the officers who travelled in that country.

From this point of view, it is unavoidable to undertake the description of fossils of which the characters can only be very imperfectly made out. It is often among such specimens that characteristic and peculiar forms occur; and it would give quite an inadequate idea of the variety of forms that occur in the Salt-range strata if all these fossils were left aside. The assigning of such specimens to genera already described often requires long and anxious deliberation; and it is only after much painstaking that one arrives at a conclusion to which genus such a fossil might be most safely referred.

Such is precisely the case with the shell which I describe under the generic name of *Spengleria*, neither the characters of the hinge, nor the pallial or muscular impressions being visible. From its external form alone it is most probable that we have to deal here with a burrowing shell of the order of the *Pholadacea;* but it is most embarassing to decide to which of the genera hitherto described the shell under consideration may be most closely related. A character by which it deviates from all the shells of the now living genera is the remarkable flatness of the shell, which is very strange. The shell must have gaped strongly all round, otherwise this flatness could barely be explained.

It seems to be quite optional whether this little shell should be considered as belonging to the *Pholadidæ* or to the *Gasterochænidæ*. In the *Pholadidæ* the genus *Martesia* could with more or less probability be quoted as the one to which the shell should be associated; but as no accessory valves could be detected, and as on the other hand, when being worked out of the rock, it seemed to be enclosed in something like a short ovate tube, I prefer to refer this little shell to the *Gasterochænidæ*, and in this family there is no other genus in which it could have been placed but *Spengleria*.

This is all that I am able to advance in support of the view thus stated—that the genus *Spengleria* was represented already at the early period of the earth's history represented by the Productus-limestone of the Salt-range.

Of the family *Gasterochænidæ* but very little is known in palæozoic rocks. A tube very likely belonging to an animal like *Gasterochæna* has been described by Eichwald from the upper carboniferous limestone of Miatchkowa, but this seems to be all. But even of the whole order of the *Pholadacea* not much more is known. M'Coy describes some tubes which he calls *Teredo antiqua;* but besides

this but very little has been detected that would indicate a greater development of the order during palæozoic times. The genus *Pholadella* of Hall, though looking very much like a *Pholas*, seems yet only doubtfully to belong to that order. Only in the mesozoic period does the order become more numerously and more variously represented, but in general the species remain scarce, except the *Procellariæ*, which are often seen in jurassic and cretaceous strata, covering large surfaces of rock with their holes.

1. Spengleria vetusta, Waagen, n. sp., Pl. XVII, fig. 11.

The only specimen of this species that has been detected up to the present is a very small shell of very thin structure, representing the right valve only.

The general form of the valve is about oval, strongly and obliquely truncated, and thus strongly gaping in front, and very likely so all round. The inferior margin of the shell is strongly sinuated, the posterior margin well rounded, and running in a gentle curve up to the beak. The shell is flat, not inflated; the beak is obtuse and very little bent over. From the beak to the inferior margin there extends a deep angular impression, dividing the shell into two unequal halves, a smaller anterior and a larger posterior half. The whole surface of the shell is covered by not very numerous concentric wrinkles, about equidistant from each other, low, well rounded at the top, and separated by equally broad shallow excavations.

The wrinkles are sinuated along the angular impression that runs from the beak to the inferior margin.

The shell is extremely thin even in the region of the beak, and seems to be devoid of any hinge teeth. It cannot be seen how the ligament, if any existed, had been inserted; nor could the pallial line or the impressions of the muscles be observed.

The tube, in which this shell seemed to be placed, when being taken out of the rock, was very indistinct. It seemed to be lined by shelly matter, but was very much compressed, and its general form could only be approximately ascertained to be oval. All doubt could not, however, be removed, as to whether this might not be only a concretionary piece of rock with shelly fragments on it, simulating a tube.

The dimensions of the specimen are as follows:—

Length of the shell	7·5 mm.
Height of the shell	6·0 „
Thickness (transverse diameter)	2·0 „
Angle of the beak	133°

Locality and geological position.—The only specimen of this species was collected by myself at Amb in a bed of sandstone at the very top of the Productus-limestone formation.

Remarks.—There is no palæozoic shell to which the present species could be particularly compared, and even among the mesozoic species there is none of any great similarity, except possibly one or other triassic form; these, however, but slightly resemble our Salt-range species.

It has been observed already in the remarks on the genus how far my generic designation of this species may be trusted. Nevertheless, the occurrence of a species of the order *Pholadacea* in palæozoic rocks is always of interest, though the existence of the family at those remote periods had been indicated by the detection of a borehole of such a shell in the mountain-limestone formation of Matchkowa by Eichwald. By the Salt-range species, it is shown, that already in palæozoic times the external appearance of the shells of that order was very much like what can be observed in the shells now living. Species belonging to the order were however apparently extremely rare during palæozoic times.

Order: MYACEA.

Family: *MYIDÆ.*

Sub-Family: *CORBULINÆ.*

Genus: EUCHARIS, Recluz.

There is a single specimen of a very small shell, which seems to belong to the above genus. On a first glance the general form of this little fossil seems not to warrant its reference to the *Corbulinæ;* but on a closer examination of the hinge, it becomes evident that we have to deal here with a species more or less allied to the recent *Corbulæ.*

Forms belonging to the family *Myidæ* are in general not common in palæozoic strata, and scarcely any shells allied to *Corbula* have up to the present been quoted from older than mesozoic formations. Hall, in the fifth volume of his Palæontology of New York, does not even mention the sub-family *Corbulinæ;* and also by Stoliczka we do not find any genus quoted from the palæozoic formations, except *Dorsomya,* Ryckh. from devonian strata.

In the palæozoic strata of the Salt-range, however, their occurs a little shell which beyond any doubt belongs to the sub-family *Corbulinæ,* and which, therefore, is of great interest as the geologically oldest representative of the family. It is remarkable that the characters of the family are already in this early species so well expressed, and this is suggestive, that the origin of the family dates yet further back in the series of formations.

Somewhat more doubtful than the family-character is the reference of this shell to the genus *Eucharis;* but, among all the genera of the *Corbulinæ,* this is certainly most allied to the present form.

The genus *Eucharis* seems already to be not very rare during jurassic times, and thence to be distributed through cretaceous and tertiary times into the recent period. In older formations, however, shells which could be referred to the genus seem to be very scarce, and, so far as is known up to the present, the Indian species seems to be the geologically oldest.

EUCHARIS GRANDÆVA, Waagen, n. sp., Pl. XVII, fig. 5.

The general form of this tiny species is elongated trapezoidal, rounded in front, truncated behind.

The beaks are very small, little prominent, and strongly pointed, not incurved. In front of the beaks there is a very small, not deeply excavated lunula. From there the anterior margin projects slightly in a well-rounded curve, and joins without proper limit the ventral margin of the shell. This latter is more or less strongly sinuated in the middle, and forms a distinctly prominent corner in meeting the posterior margin. The latter is nearly straight, giving thus an angular outline to the posterior end of the shell.

On the dorsal side of the shell there is a very distinct and strongly defined area. The dorsal margin is but very slightly arched.

From the apex towards the posterior lower corner of the shell a sharp angular slightly curved ridge descends, and the same from the apex to the upper posterior corner, thus marking off the dorsal area. Anteriorly there extends a broad low elevation from the apex to the ventral margin. Between this anterior elevation and the posterior ridge a broad depression extends.

The whole surface of the shell is covered by imbricating concentric folds, which are more strong and numerous near the margin and are almost quite absent near the beaks. Between the folds very fine striæ of growth can be observed. Near the posterior end of the shell, its surface appears somewhat granular; but this may only be the effect of weathering.

Of the hinge, only that of the left valve is known. It consists of a large triangular tooth, below and somewhat in front of the beak. Behind this, there is a deep and large triangular pit cut out in the hinge margin, which seems to have served partly for the reception of the tooth in the opposite valve and partly for the insertion of the cartilage. Behind this pit the hinge margin is somewhat thickened, but no trace of a tooth is observable. Above, there is a distinct flatly arched groove extending a short way behind the beak for the insertion of an external ligament.

Though one of the specimens is partly a cast, yet no trace of the muscular or pallial impressions can be observed on it, the very small dimensions of the species making the preservation of such characters very uncertain.

The shell seems to be quite equivalved; only the superficial ridges extending from the beak to the margins seem to be less strongly developed in the right than in the left valve.

The dimensions are as follows :—

Entire length of the shell	5 mm.
„ breadth	3 „
Thickness of both valves	36 „
Apical angle	110°

Locality and geological position.—There are only two specimens of this species known to me. Both were collected by myself at Amb in a whitish sandstone forming the topmost bed of the upper division of the Productus-limestone.

Remarks.—This little species is interesting not only because its occurrence in palæozoic strata carries the origin of the genus so very far back in the series of formations, but also because it is a new proof for the 'mixed' character of the Pelecypod fauna of the Salt-range.

The determination of this little fossil as belonging to the genus *Eucharis* is not beyond every doubt, as the characters of the muscular impressions and the pallial line could not be observed, but the hinge of the left valve, which is very clearly visible, exhibits all the characters of the hinge of the shells belonging to the family *Corbulinæ* so very clearly, that its reference to that family cannot be very much doubted; but then the genus *Eucharis* is certainly the one to which it is most nearly related.

There is no shell in palæozoic strata which could be compared to the present species; only in jurassic times species of the genus begin again to appear. Thus this species is very apt to give a more or less mesozoic appearance to the Pelecypod fauna of the palæozoic strata of the Salt-range.

Family : *ANATINIDÆ.*

Sub-Family : *ANATININÆ.*

Genus : CARDIOMORPHA, Koninck.

This is a thoroughly palæozoic genus, and it would seem rather strange should it be immediately associated with *Eucharis*, which has been described on the foregoing page. This is, however, not the case. The single species of *Cardiomorpha* I have to describe, comes from much older deposits than *Eucharis grandæva.*

The genus *Cardiomorpha* was originally described by Koninck from the carboniferous strata of Belgium. Since that time it has been detected in numerous species, in the devonian formation in Europe and America, but it seems to be very rare in silurian strata.

From the carboniferous upwards the genus becomes, as it seems, very soon extinct. There have been quoted some two or three species from the permian formation; but in the trias, as far as is known to me, not a single species exists.

The characters of the genus consist chiefly in a very thin shell, thin as paper, a transversely elongated form, edentulous hinge, and external ligament. The sculpture of the shell is composed of more or less fine concentric folds.

As has been stated above, the genus is represented by a single species in the palæozoic deposits of the Salt-range.

1. CARDIOMORPHA INDICA, Waagen, n. sp., Pl. XVII, fig. 6.

The general form of the shell is roundish, transversely oval, strongly inflated, equivalve.

The little beaks are situated quite anteriorly, nearly terminal, and are inflated and strongly incurved. The dorsal-hinge margin is flatly arched, and joins in a perfectly rounded curve the posterior margin which is entirely rounded, not truncated.

The ventral margin also forms a flat arch, and joins the narrowly rounded anterior margin of the shell without demarcation.

Anteriorly to the beaks, there is a not very deep indistinct lunula.

The shell is extremely thin, and sculptured by fine concentric folds, which, however, do not quite follow in their direction the ventral and posterior margins, but run in a somewhat diagonal direction from the ventral margin up to the dorsal one, in this respect resembling slightly the folds which are exhibited on the shell of *Ceromya*.

Of the hinge apparatus, nothing can be seen.

The dimensions of the little shell are as follows:—

Entire length of shell	18 mm.
„ breadth	13 „
Thickness of both valves	14 „
Apical angle	112°

Locality and geological position.—There are two specimens of this species in the Salt-range collection, one only an impression on the rock, the other a not quite perfect cast. Both are preserved in a dark micaceous shale of a rusty grey colour, nearly identical in appearance with the rock in which *Hyolithes orientalis* W. is preserved; but the brown quartz grains, which are present in the latter, are absent in the rock containing *Cardiomorpha indica*. Both specimens were found by Mr. Wynne at Saiduwali, in the Trans-Indus continuation of the Salt-range. As appears from Mr. Wynne's description of the section at Saiduwali, the specimens of *Cardiomorpha indica* as well as those of *Hyolithes orientalis* seem to have come from one group of beds, to which he gives the No. 8, and which he describes as dark grey concretionary shales 100 to 130 feet thick, forming part of his "Boulder group" below his "carboniferous."[1]

Remarks.—This species is more or less nearly related to some carboniferous species. The form which seems to be most similar to the present species is *Cardiomorpha concentrica* L. G. de Koninck, from the lower carboniferous strata of Bleiberg. The specimen figured by Koninck is considerably smaller than the

[1] Memoirs, Geol. Surv., India, Vol. XVII., Pt. 2, p. 71.

Indian shell, but otherwise the similarity is very great. There are however differences, which make a distinction not very difficult. The general form of the Indian shell is more rounded, and not truncate behind, as is the case in the species from Bleiberg; and besides this there is the sculpture, so characteristic in the present species by its peculiar position, that by this character alone it deviates widly from other species of *Cardiomorpha*.

This sculpture is worthy of special notice. Chénu in his Manual has advocated the view that the genus *Cardiomorpha* should be considered as identical with *Ceromya* of Agassiz. It is then of high interest to observe a sculpture, similar to that of *Ceromya*, in a species which from its general appearance will have to be counted with *Cardiomorpha*. It seems thus evident, that the two genera are more or less blending together; nevertheless I think that Stoliczka is perfectly right in keeping them separate, as the *Ceromyæ* of the mesozoic formations possess a hinge apparatus which is absent in the palæozoic species. The surface sculpture of this *Cardiomorpha indica*, however, is again a proof of the truly transitional character between palæozoic and mesozoic types of the Pelecypod fauna of the Productus-limestone of the Salt-range, to which I have already often had occasion to draw the special notice of the reader.

Genus: ALLORISMA, King.

Nothing seems more difficult than to distinguish the present genus from all those forms in mesozoic formations which have received from Agassiz a number of generic names, to which must yet be added the genus *Myacites* of Schlotheim. This distinction is, however, so very difficult because in very rare cases only can the hinge apparatus of the shells be observed in a tolerably complete condition. Generally only casts occur, on account of the great thinness of the shell in all these forms; it thus very easily gets destroyed in the process of fossilisation.

If the hinge is preserved at all, a distinction of the different genera is not difficult; but even in very excellently preserved specimens, it is exceedingly difficult to make the hinge visible and clear it from the adhering rock, and only of very few of the genera into which the old genus *Myacites* has been divided have really good specimens representing the hinge been figured.

The Salt-range specimens of *Myacites* are not in a condition to allow of any observation of the hinge. Most of the specimens are casts; some still retain their shell; but the latter are preserved in such excessively hard rock, that there is no hope of making visible the thin shelly lamellæ of which the hinge of these fossils is generally composed.

In such case nothing but the general form and the surface sculpture of the shell remains for the generic determination of these fossils, but of what value such a determination can be may easily be imagined.

There are, however, yet some reasons why the fossils I shall describe presently

should belong with more probability to the genus *Allorisma* than to any other. As far as it can be observed in the casts, the hinge seems to have been edentulous. In the specimens in which the shell is preserved there exists behind the beaks a sharply defined area, as in *Allorisma elegans*, King, and the surface of the shell is very closely granulated. All these characters united seem to indicate the genus *Allorisma*, and thus I have placed these shells in that genus.

There seem to occur four species of this genus in the palæozoic deposits of the Salt-range, one of which, however, is only represented by a not very well preserved cast, so that I do not think it advisable to give a name to it. The other three can be more strictly defined, and I shall describe them under the names of *Allorisma perelegans*, W., *Allorisma pleuromyoides* W., and *Allorisma dubium*, W.

All these species recall in their general form the typical species of *Allorisma*, of the carboniferous formation much less than they do more recent species. The first of the three seems to be a rather near ally of *Allorisma elegans*, King, from permian beds, and is distinct chiefly by the little development of the ridge which extends in King's species from the beak to the lower posterior margin. The other has very much the appearance of *Pleuromya*, and if found in mesozoic strata would be considered without hesitation as belonging to the latter genus. I cannot positively assert whether it be not after all really a *Pleuromya*. The third species has the hinge-area rather largely developed, assuming thus somewhat the appearance of an 'area'; but the great thinness of the shell and its apparently granulated surface-sculpture make its position in the genus *Allorisma* very probable.

1. Allorisma perelegans, Waagen, n. sp., Pl. XVII, figs. 3, 4.

This is a medium sized species, of elongated oval general form, tolerably compressed, apparently perfectly equivalve, closed in front and slightly gaping behind.

The beaks are very little prominent, broadly rounded, and little incurved. Anteriorly to the beaks there is a very small and very indistinct lunula. The anterior part of the shell is very short and little prominent, the beaks being subanterior. The margin of the shell is in this anterior part rather narrowly arched, and joins the ventral margin in an oblique curve. The latter is not quite straight but nearly so. The posterior end of the shell is broader than the anterior one and terminates in a broadly rounded curve. The hinge margin is straight. No hinge area is visible in casts; but when the shell is preserved, there extends a distinct ridge from the beak to the posterior end of the hinge margin, thus marking off a distinct but very narrow hinge area.

As far as can be observed in the specimens at hand, the hinge seems to have been edentulous. The mode of the insertion of the ligament cannot be observed in any of the specimens. The surface of the shell is not entirely smooth. There extends a very indistinct and broadly rounded but yet characteristic ridge from the beak to the posterior margin of the shell. This is crossed by many irregular con-

centric folds and striæ of growth, which extend from the hinge margin over the whole shell to its anterior part, separating the general outline of the margins. Besides this sculpture there appears under the lens, not visible to the naked eye, a very fine granulation, so fine that it requires a rather strong magnifying power to make it distinctly visible. The granules are arranged in quincunx and thus form diagonal rows on the shell.

Both valves are very little inflated, rather flat. They are thickest near the umbones, and more or less flattened towards the ventral margin.

The measurements of a specimen from Jabi are as follows :—

Entire length of the shell	41·5 mm.
„ breadth	25 „
Thickness of both valves	18 „
Apical angle	135°

Locality and geological position.—This species is not very rare in the palæozoic deposits of the Salt-range, but up to the present it has only been found in the upper division of the Productus-limestone. It has been collected by myself at Jabi (2 specimens) in the same bed in which also *Cyclolobus oldhami* was obtained, at Chidru (2 specimens) in the same bed out of which many specimens of *Xenodiscus carbonarius* W. were collected by myself. At the same locality it extends from this bed up to the topmost layer of the Productus-limestone where also a specimen of this species was found by myself. Another specimen was found by me at Khura, there also in the upper division of the Productus-limestone; and the last specimen I collected was from West of Khura, out of the same beds. In Dr. Verchere's collection there were two specimens of this species which were no doubt found in the Trans-Indus continuation of the Salt-range, though the exact locality where they came from is not known. The rock in which they are contained, a yellow sandstone with many shelly fragments, clearly indicates that they also came from the upper division of the Productus-limestone. One of the specimens bears the inscription "*Trilobite*," by Dr. Verchere, and has evidently been considered as such by him. On the whole piece of rock, there is, however, nothing that could be compared to such a fossil. Besides the *Allorisma*, there are fragments of a small smooth *Chonetes*, of a *Spirifer*, and of several specimens of *Athyris*, but not a trace of a *Trilobite*.

Remarks.—The generic determination of this species is not above every doubt. The general form and the fine and close granulation of the shell seem to indicate the genus, but it cannot be made out with certainty whether the hinge was really edentulous, and thus the genus to which the shell belongs cannot be quite satisfactorily settled.

Of the species which might be compared to the present one, there is chiefly *Allorisma elegans*, King, which shows the greatest similarity, though of this species the figures given by different authors differ very widely in their general aspect. As representing the typical form, King's figure must certainly be taken; but this

as well as the figures in Geinitz's Dyas show one principal difference from our present species, this is the much narrower anterior part of the shell. Besides this character, most figures of *Allorisma elegans*, the typical one included, show very distinctly the ridge which extends from the apex to the lower corner of the posterior margin, whilst it is very flattened, rounded, and barely perceptible in the Indian shell.

These differences well suffice to distinguish the Indian fossil as a proper species.

2. Allorisma pleuromyoides, Waagen, n. sp., Pl. XVII, fig. 9.

The general form of this middle-sized species is oval, not much longer than broad, narrow in front, broadly rounded behind, with prominent anterior beaks and rather compressed valves, gaping posteriorly.

The beaks are thick, rounded, strongly prominent, and not much incurved. There is a small, indistinct but deep lunula in front of them. The anterior margin of the shell is narrowly rounded and somewhat cut out where it joins the ventral margin. The latter is flatly rounded, short, and unites with the posterior margin without precise limit. There is no posterior truncation, but the margin of the shell is there well rounded, forming a tolerably flat arch. The hinge margin is straight, but no trace of a hinge area is visible.

The hinge itself cannot be observed in any of the specimens, it seems to have been edentulous.

The surface of the casts, which only are accessible to my observation, is covered by numerous concentric unequal wrinkles. From the apex to the anterior part of the ventral margin there extends a very flat depression of the shell, as occurs in most of the species belonging to the genus *Pleuromya*.

As no specimen with the shell preserved has been examined, I cannot say whether the surface was granulated.

Of muscular and pallial impressions nothing can be observed on the casts.

The measurements of a specimen from Chidru are as follows:—

Entire length of the shell	45 mm.
„ breadth „	31 „
Thickness of both valves	20 „
Apical angle	125°

Locality and geological position.—This species is somewhat less common than the preceding one, but seems to be also restricted to the upper division of the Productus-limestone. It has been collected (two specimens) by myself, together with the preceding species, at Chidru in the same bed as that in which *Xenodiscus carbonarius* is abundant. Another specimen was found by me at Chidru but somewhat lower in the series, yet belonging to the upper division of the Productus-limestone.

Remarks.—Also in this species the specimens are too imperfect to allow of a proper generic determination, and I have placed this species in the genus *Allorisma*

simply because the hinge seems to have been edentulous, though this character also is not quite certain.

As to species there is one very similar to the present shell, that is, *Lutraria primæva*, Portl., from Clogher, out of a gritty limestone of the carboniferous formation. Like the present species this one also resembles very much a *Pleuromya*, and in general shape is very much like our *Allorisma pleuromyoides*, but in the Indian shell the ventral margin is much more curved, not so straight, and the posterior part of the shell much shorter than in Portlock's species.

It is barely possible, with species geographically so widely separated, to say whether any close connection may exist. If both species had been found in the same geographical district, but in beds of different geological age, they would certainly have to be considered as in developmental connection to each other. As the matter stands, however, it is barely possible to say whether they are vicarious forms, or even perfect strangers to each other of only accidental similarity.

3. Allorisma, *spec. indet.*

There is a single cast of a shell in the Salt-range collection which very likely belongs to *Allorisma*, but which is too badly preserved to allow of a proper description.

The general form of the shell is very much like that of a *Gresslya* out of secondary formations. It is elongated oval, with anterior beaks, somewhat inequivalve, the right valve being the larger one, somewhat gaping behind, but the internal rib along the posterior part of the hinge line in the right valve, which is characteristic for *Gresslya*, is decidedly absent in the Indian shell. The posterior end of the shell is narrow, the hinge line sloping towards the posterior end. The shell is tolerably inflated and its surface covered by concentric wrinkles.

All these characters show that this specimen cannot belong to any of the above described species, and it indicates certainly the existence of a third species of *Allorisma;* but there must be found better materials for this species to be properly described.

The measurements are as follows:—

Entire length of the shell	43 mm.
„ breadth „	29 „
Thickness of both valves	20 „
Apical angle	118°

Locality and geological position.—The only specimen was collected by myself at Jabi in the same bed in which I found *Cyclolobus oldhami.*

4. Allorisma dubium, Waagen, n. sp., Pl. XVII, fig. 7.

This is a rather small species, of elongated oval shape, and somewhat distant beaks. The valves are inflated and seem to be closed in front and but slightly gaping behind.

The beaks are very little prominent, rounded and sub-anterior. The hinge line is long and straight. The anterior part of the shell is short, its margin narrowly rounded. The lunula in front of the beaks is barely at all developed, shallow and very indistinctly marked off. The ventral margin is not quite straight but nearly so. Posteriorly the shell is indistinctly and obliquely truncated, the posterior margin forming an obtuse angle with the hinge line, and then, after having been nearly straight for a certain distance, it suddenly bends round to meet the ventral margin.

Along the hinge line there extends a well developed area, which is, however, not distinctly marked off from the remainder of the surface of the shell.

The shell is tolerably inflated and very equally rounded all over. The surface sculpture consists solely of more or less fine concentric striæ of growth. There is a very indistinct appearance of granulation, possibly only caused by the mode of preservation.

The substance of the shell is thin, like paper.

The hinge seems to have been edentulous, though a proper observation of this character is impossible.

The measurements of a specimen from Katwáhi are as follows:—

Entire length of the shell	21 mm.
„ breadth „	10 „
Thickness of one valve	5 „
Apical angle	135°
The species may attain a length of about	30 mm.

Locality and geological position.—There are four specimens of this species in the Salt-range collection. They were found by myself in a friable sandstone in the middle region of the upper division of the Productus-limestone, near Katwáhi, on the road from that place to Shahpur.

Remarks.—As in the preceding species so also in this one, the generic position is not certain on account of the imperfect observation afforded by the rather badly preserved specimens. As this species, however, seems not to be rare in certain beds of the upper division of the Productus-limestone, I did not like to pass it over in silence. Of all the genera hitherto described, it can be with most probability attributed to the genus *Allorisma*, though the well-developed area does not agree very well with that genus.

As to species the present one resembles most *Allorisma perelegans*, W. described above. It is, however, distinct by its strongly developed area, its posterior truncation and a more oblique shape of the valves. *Allorisma elegans*, King, has a similarly, though not so strongly developed area, but it has at the same time a strong ridge extending from the apex to the lower posterior angle of the shell which is absent in *Allorisma dubium*. Besides this, the latter species is also more oblique than *Allorisma elegans*. Also *Psammobia subpapyracea*, King, might be compared, but this species seems to be less inflated and devoid of an area.

Genus: PALANATINA, Hall.

There is a rather small specimen of a *Myacites* in the Salt-range collection, the generic position of which is very doubtful, as it is impossible to observe any of the deciding characters for the determination of the genus. But even if these characters were better observable than they are, it would be more or less doubtful how this shell would have to be assigned.

There are several genera which were all comprised under the old name of *Myacites* by Schlotheim, but which more recently have been separated, chiefly by Agassiz, though by the latter author all the forms have been designated by new names, leaving no room for the name *Myacites*, which for certain forms must beyond doubt take priority. But the question as to which forms these ought to be is not yet settled definitively. In recent publications the name *Myacites* is generally retained for the triassic (Muschelkalk) species only. Most of the latter, however, have been placed by Agassiz in his genus *Pleuromya*, and the question arises whether the entire genus *Pleuromya* of Agassiz should be considered identical with *Myacites*, or whether the triassic species form a group of shells which has not received proper attention by Agassiz, and which might generically be distinguished from *Pleuromya*, and for which the name *Myacites* might be retained.

The only information we have about the hinge apparatus of a true *Myacites* is, as far as I am aware, from Giebel, in his fossils from Lieskau. The species figured there has been called by Giebel *Myacites elongatus*, but has been ascertained afterwards by Seebach to represent *M. grandis*, Gdf. I had occasion myself to expose the hinge apparatus of several jurassic species of *Pleuromya* from the adhering rock, and I can only state that the hinge of *Pleuromya* is widely different from that of *Myacites grandis*, Gdf., as it has been figured by Giebel. *Pleuromya* has an oblique lamellar process below the beak, which is entirely absent in *Myacites*, and thus it seems probable that the triassic species form a proper generic division different from *Pleuromya*.

One triassic species has also been transferred by Agassiz to his genus *Arcomya*, but this is scarcely a reason for considering this genus also as identical with *Myacites*. The general shape of *Arcomya* at least does not agree with the typical forms of *Myacites*, as *M. musculoides*, *grandis*, &c. *Arcomya* has by most writers been considered identical with *Homomya*. In both genera the hinge seems to be edentulous, though this question is not yet quite settled for *Arcomya;* an external ligament supported by distinct nymphæ is present, and the shells are smooth, not granulated; but the species of *Homomya* generally possess a tolerably thick heavy shell like *Panopœa*, whilst in the species of *Arcomya* the shell is very thin and fragile. Besides this the general form of the shell is roundish oval, very much resembling *Panopœa;* in *Arcomya*, on the contrary, the general form of the shell is rather elongated, the beaks being not so much anterior, and in most

cases there extends a prominent angular ridge from the apex to the lower posterior angle of the shell, and thus the two genera might very well be kept separate.

The geological distribution of the genus *Arcomya* is very difficult to define, as in older formations the whole order of the *Myacea* seems to be but sparingly represented. There is the genus *Tellinomya* of Hall, which generally is quoted as a representative of the order during older palæozoic times, and which in its general form shows great similarity to the Indian shell I have to describe; in fact, this shell occupies in its general form about the middle between the *Tellinomyæ* and the typical forms of *Arcomya* as they occur in middle and upper jurassic strata. The typical species of *Tellinomya*, *T. nasuta*, has been shown, however, by Salter to possess hinge teeth very like those of *Nucula*, and thus this genus has altogether been removed from the *Myacea*. Nevertheless, there remains some doubt whether already in palæozoic strata there did not exist a genus of the general form of *Tellinomya*, and really belonging to the order *Myacea*, as in many forms the hinge is not known, and the general characters are very similar indeed to *Arcomya*. If this were the case we should have to consider these shells as the ancestors of *Arcomya*.

In a pamphlet[1] that is not easily procured Prof. Hall has, however, described another genus, which seems to be rather closely allied to *Arcomya;* this is the genus *Palanatina*, Hall. From the description alone it would be rather difficult to make out the close resemblance between the typical species *Palanatina typa*, Hall, and *Arcomya:* but Mons. J. Barrande, who, as is well known, favours to the utmost of his power every scientific endeavour, had the great kindness to communicate to me the unpublished plates of the first part of the fifth volume of the Palæontology of New York which Prof. Hall had given him, and thus I have been enabled to compare the Indian fossils with Hall's genus and with *Arcomya*.

The typical species of *Palanatina* are inequivalve, the left valve being slightly larger than the right one. The beaks are sub-anterior and little prominent; there extends a sub-angular oblique ridge from them to the posterior end of the shell and "a broad, shallow, antero-mesial constriction passes obliquely from beak to base." The valves are united by an external ligament, and the hinge consists in small hook-like processes, one in each valve below the beak; muscular impressions small and indistinct, pallial impression unknown. The whole form of the shell is more or less elongated trapezoidal; gaping at both ends, the shell seems not to be granulated.

From this description alone it is very difficult to decide what sort of a shell we have here to deal with, but the figures show that it is one very much like *Arcomya*. It is, however, absolutely impossible to tell whether the genus *Palanatina* should be united with *Arcomya*, as the form of the pallial impression is not known in the former genus. Otherwise all the characters are perfectly identical. Also the *Arcomyæ* are generally slightly inequivalve, and in some species at least possess

[1] "Preliminary Notice of the Lamellibranchiate Shells," &c. Prof. Hall kindly sent me this pamphlet on my asking for it. I may be allowed to offer here my best thanks to him for his kindness.

small hook-like processes below the beaks. Thus there is every probability that *Arcomya* and *Palanatina* may be identical, though this cannot be proved. Until, however, such proofs will be accessible it is beyond doubt better to retain Hall's name than to make an identification without proper foundation.

The Indian shell, which I shall describe under the name *Palanatina Indica*, bears all the characters of an *Arcomya* or *Palanatina*, but the pallial impression cannot be observed, and thus I prefer to retain it in Hall's genus than to place it in the genus *Arcomya*, and thus to assert a character the existence of which I could not verify.

All the species of *Palanatina* as yet known are from the upper devonian formation.

1. Palanatina Indica, Waagen, n. sp., Pl. XVII, fig. 8.

The general outline of this rather small shell is nearly trapezoidal, with subanterior beaks. It is tolerably inflated, closed in front and gaping behind; not quite equivalve, the left valve being somewhat larger.

The beaks are pointed, not much incurved, and somewhat distant from each other. The hinge line is straight, extending over the whole length of the shell in front as well as behind the beaks. The anterior margin joins the hinge line under an obtuse angle; it is flatly rounded, somewhat truncated, and there is a rounded off corner, where it unites with the ventral margin of the shell. This latter is very flatly arched, nearly quite straight, and joins the posterior shell margin nearly at right angles. Posteriorly the shell is distinctly truncated and strongly gaping, the margin of the shell there running up in a nearly vertical line to meet the hinge line at about a right angle.

It cannot be seen whether an external ligament existed, nor has it been possible to make the hinge apparatus visible.

On the surface of the shell the most characteristic feature is a sub-angular prominent carina, which extends from the beaks in an oblique direction to the point where the ventral and posterior margins of the shell unite. Behind and above this carina there is a triangular, somewhat flattened, space, and below and in front of it the shell is flattened but not impressed.

The body of the shell is very thin, covered only by fine concentric wrinkles and striæ of growth. Any granulation of the shell is entirely wanting.

The dimensions of the only specimen are as follows:—

Entire length of the shell	22 mm.
„ breadth „	12 „
Thickness of both valves	9 „
Apical angle	145°

Locality and geological position.—The single specimen of this species which has served for the description was collected by myself at Jabi in a bed situated above the Cephalopoda bed containing *Cyclolobus oldhami*, &c., and thus forming part of the top beds of the upper division of the Productus-limestone.

Remarks.—Already in the notes on the genus it has been remarked that the position of this shell in the genus *Palanatina* is chiefly founded on negative evidence. From the general form, and the condition of the shell, it is certain that we have to deal here either with an *Arcomya* or with a *Palanatina*. As the form of the pallial impression is unknown in *Palanatina*, and the same is the case in the present shell, I have chosen this latter name. It is, however, not of great consequence which of the two names may be applied, as the two genera seem to be so very nearly allied to each other that both will be considered by the greater number of naturalists as identical.

Of the species which have up to the present been described under the name of *Palanatina* none is specifically similar to the present form; of *Arcomyæ*, *Ar. inæquivalvis* from the Muschelkalk formation might be compared.

Order: LUCINACEA.

Family: *LUCINIDÆ.*

Sub-family: *CORBINÆ.*

Genus: SPHÆRIOLA, Stoliczka.

There is among the palæozoic fossils of the Salt-range a little shell, which according to the characters of the hinge, and its sculpture, is more or less nearly allied to *Corbis*, and which cannot be better placed but in Stoliczka's genus *Sphæriola*, though it must be remarked that this position is only tentatively the best one. It is by no means certain whether the shell might not be with as much right placed in the genus *Pachydomus*, and thus be removed from the *Lucinidæ* altogether, but the hinge of *Pachydomus* is as yet very little known, and the sculpture of the shell here under consideration differs considerably from that of Dana's genus. Also the genus *Neo-Megalodon* of Gümbel may be compared; but in this case the similarity is only a rather remote one. On the whole, the position of this little shell in the *Corbinæ*, and especially in the genus *Sphæriola*, is the most probable one. If better materials were procurable a new genus would possibly have to be created.

The genus *Sphæriola*, as defined by Stoliczka, seems to stand very well, and is sufficiently distinct from *Sphæra* by the characters of the hinge. In general appearance the present genus is more nearly related to *Corbis* than is the case with *Sphæra*, but it can readily be distinguished from the former by its roundish outline, inflated valves, and a hinge in which the lateral teeth are obsolete.

As far as our knowledge at present goes, the Indian shell seems to be the geologically oldest representative of the genus. But even of the whole family of the *Corbinæ* but very little is known during palæozoic times, and species which with certainty belong to the family have only been described up to the present out of triassic beds.

Thus the little shell which I have to describe here deserves some interest as the geologically oldest representative of a whole group of forms.

2. Sphæriola grandæva, Waagen, n. sp., Pl. XVIII, fig. 13.

The general outline of this little shell is nearly circular, with a distinct lunula in front of the beaks, and a strongly arched surface, covered by a concentric sulcation.

The beaks are strongly prominent and distinctly incurved, obtusely pointed. There is a small but deep and distinctly defined lunula in front of them, which is of about oval shape. The anterior margin of the shell is deeply excavated where the lunula is situated. In front of the latter the margin bends round in a very narrow curve to meet the ventral margin in a flat arch. The ventral margin exhibits a very regular flat curve. Posteriorly the shell is slightly truncated, the posterior margin descending in a low oblique arch from the beaks to the lower posterior corner of the shell. Where the posterior margin meets the ventral one there is a slight sinuation of the outline, corresponding to a flat furrow, which extends from the beaks to the ventral part of the shell, about parallel in its direction to the posterior shell margin.

Posteriorly to the beaks there extends a kind of indistinct hinge area, limited above by an edge of the shell and below by the furrow, which served for the insertion of the ligament.

The hinge line is strongly arched.

The hinge of the left valve, which alone is preserved, consists of two not very large diverging cardinal teeth, rather close together without any deep pit between them. The anterior one of these is more horizontal, the posterior more vertical in its position. Anteriorly and posteriorly to these two teeth there are deep grooves, of which the posterior one is larger than the anterior. Every trace of lateral teeth is wanting. Posteriorly to the incurved beaks and above the hinge margin there extends a deep furrow for the reception of a strong sub-external ligament.

The surface sculpture of this little shell is very characteristic. There is a strong concentric striation or folding, which consists of about 30 to 35 rather sharp not very high folds in parallel position with the striæ of growth, and separated from each other by about equally broad furrows. On the posterior part of the shell this concentric system of sculpture is crossed by a number of radiating striæ, extending from the beak to the ventral margin. Besides these there is a kind of furrow running down from the apex to the posterior margin, as in some species of *Lucina*, for instance *Lucina Pennsylvanica*, L., marking off distinctly a narrow triangular posterior part of the shell.

The substance of the shell is tolerably solid, and its internal margin is, so far as can be observed, smooth, not crenulated.

The dimensions of the only specimen are as follows :—

Entire length of the shell	8 mm.
„ breadth „	7·5 „
Thickness of the left valve	3 „
Apical angle	108°

Locality and geological position.—The only specimen of this species that has been detected up to the present was found by myself at Virgal in the topmost bed of the upper division of the Productus-limestone.

Remarks.—The generic position of this shell is very difficult to decide upon, first because the dimensions of the specimen are so very small, then because the muscular and pallial impressions cannot be observed, and last, not least, because the characters exhibited by the shell are really somewhat conflicting. I have more or less provisionally placed the species in the genus *Sphæriola*, but if better materials should be found it may happen that the shell will have to be transferred to some other genus, or else form the type of a new one.

As to species there is none which could be in particular compared to the present shell.

Sub-Family : *LUCININÆ.*

Genus : LUCINA, Brug.

The genus *Lucina* has before now been quoted in palæozoic deposits, but it seems to be very rarely the case that the determination of the fossil as a *Lucina* was founded on the examination of the internal characters of the shell. Already by M'Coy, in his Carboniferous Fossils of Ireland, a species of *Lucina* has been described, and as far as can be judged from the external appearance of the fossil, it seems highly probable that the shell really belongs to the genus; but the hinge apparatus has never been examined, and thus the existence of the genus during carboniferous times has remained still doubtful. Of two other species (*Lucina dunoyeri* and *egertoni*), quoted by Bigsby in his "Thesaurus Devonico-Carboniferous," I could not get any exact information.

In devonian strata the genus has been much more frequently quoted, but here also in very few cases has the hinge been examined. Nevertheless, from what is known of these shells, it seems to be beyond doubt that the genus *Lucina* existed during devonian times; and thus its continuation during the later palæozoic periods might be expected; it is therefore somewhat surprising to find that the genus is almost entirely absent in carboniferous times, and has not up to the present been found in permian strata, though it is numerously represented in the mesozoic formations.

This apparent gap is at least partly filled up by a small species from the palæozoic deposits of the Salt-range, which by the characters of its hinge belongs, beyond any doubt, to the genus *Lucina*.

1. Lucina progenitrix, Waagen n. sp., Pl. XVIII, figs. 14, 15.

This species never attains any considerable size. Its general outline is roundish, a very little higher than long, with prominent contiguous beaks and rather compressed valves.

The prominent beaks are small, pointed, and rather strongly incurved towards the front, and are just median in their position. In front of the beaks there is a distinctly defined and deeply excavated lunula of elongated oval shape. The anterior margin of the shell is deeply sinuated at the lunula. Otherwise the margin is continuous all round, and no separated anterior, ventral, or posterior margins can be distinguished.

Behind the beaks there extends a deeply excavated, long, lancet-shaped area, limited on both sides by high, sharply defined crests.

The surface of the shell, which is moderately arched, is covered by not very numerous (about twenty) concentric folds between which very fine striæ of growth are visible.

The hinge of the left valve, which only is known to me, consists in one tolerably strong and well developed cardinal tooth, with a groove in front and behind. A very rudimentary second cardinal tooth, situated behind the posterior groove, is slightly indicated. Behind this second tooth there extends a deep but not very broad furrow along the flattened hinge margin for the reception of an altogether internal ligament. Where the furrow terminates a distinct posterior lateral tooth is present; it has an elongated conical shape. Anteriorly the hinge line is excavated, as far as the lunula extends. Below the anterior termination of the lunula, an anterior lateral tooth seems to occur; but this part of the hinge is very much concealed by very hard rocky matter. The interior peripheral shell-margin is smooth.

The substance of the shell is of moderate thickness.

The measurements of a specimen from Virgal are as follows:—

Entire length of the shell	11 mm.
Entire breadth „	11 „
Thickness of both valves	6 „
Apical angle	102°

Locality and geological position.—This species seems not to be very rare in the palæozoic deposits of the Salt-range, but, so far as observed up to the present, to be restricted to the topmost beds of the upper division of the Productus-limestone. It has been collected in this geological position by myself at Chidru (one specimen, left valve), at Virgal (bed No. 1 of my note-book, 1 specimen duplicate), at Amb (1 specimen, right valve), at Khura (1 specimen, left valve), and at Kufri (1 specimen) in thedivision No. 14 of my note-book of the section there.

Remarks.—This little species has a very great resemblance to certain *Astarte;* the completely internal ligament gives, however, sufficient evidence of its being a *Lucina*. Even if this genus is taken in a restricted sense, I think this species will still have to be counted with it; as the well-developed lateral teeth, the concentric striation and moderate thickness of the shell show beyond doubt that this fossil belongs to *Lucina* proper.

In the comparison of this species, however, with other forms, it is necessary also to take into consideration those shells which have been described by former authors as *Astarte*.

From carboniferous strata, a great many species of *Astarte* have been described by de Ryckholt; but in none of them has the generic position been proved correct by the examination of the hinge. Some of the species are in general outline somewhat similar to our *Lucina*, but all can be distinguished from it without difficulty. Species of *Astarte* have also been described by de Koninck; but according to the figures representing the hinge, the generic determination seems to be correct, and thus these shells do not require close comparison with the present species.

In the permian formation, a shell has been described by Keyserling under the name of *Cardiomorpha minuta*, which is quoted in d'Orbigny's "Prodrome" as *Lucina minutissima*, Orb. In general outline this shell does much resemble a *Lucina;* but the internal characters have not been determined. From our present species it is easily distinguishable by its much finer concentric striation and more excavated lunula. Of *Astarte* there are several species in the permian beds. From *Astarte valisneriana* the present species is distinguishable by its more circular form and central beaks, from *Ast. tunstallensis* by its coarser concentric striation. A number of species of *Astarte* from Nebrasca have been described by Geinitz, but all of them are easily distinguishable from *Lucina progenitrix*, W.

2 (?) Lucina Bombifrons, Waagen, n. sp., Pl. XXIV, fig. 9.

Though the internal characters of this little species are unknown, yet I venture to place it in the genus *Lucina*, simply on account of its great similarity to the preceding species.

The general outline of this species is nearly quite circular, strongly inflated.

The beaks are prominent, pointed, and distinctly enrolled towards the front, quite median in their position. There is a large oval lunula in front of them, which reaches nearly halfway down the entire height of the shell. The area behind the beaks is very narrow, and shorter than the lunula. The margins of the shell are all continuous.

The surface of the shell is very strongly arched, and covered by not numerous concentric folds, ten to twelve in number, between which very fine concentric striæ of growth seem to be present, but cannot be distinctly seen.

The hinge is covered up by the rock, which cannot be removed. The measurements of a small specimen from Chidru are as follows:—

Entire length of the shell	6 mm.
Entire breadth „	6 „
Thickness of both valves	5 „
Apical angle	100°

Another somewhat fragmentary specimen indicates that the species attained greater dimensions than are indicated by the above measurements It has a length of 9 mm.

Locality and geological position.—There are two specimens of this species in the Salt-range collection. One of them was found by myself at Chidru, in the top bed of the upper division of the Productus-limestone. Another specimen was collected by Dr. Oldham, also near Chidru. According to the rock in which it is contained, it also comes from the top beds of the upper division of the Productus-limestone formation.

Remarks.—This species is, in its general form and ornamentation, very nearly allied to the previously described *Lucina progenitrix*, and is chiefly distinct from it by a strongly inflated form and larger lunula. Of other palæozoic species, none can be particularly compared. In mesozoic rocks there are some which in their outward appearance are similar to the present species, but they decidedly belong to the genus *Astarte*, whilst the present species is very likely a *Lucina*.

The generic position is, however, as has been stated above, not quite certain, and only the very great similarity to *Lucina progenitrix* induces me to consider this species also as belonging to the genus *Lucina*.

Genus: LORIPES, Poli.

This genus has by many writers not been acknowledged as forming a wholly separable group of forms among the *Lucinidæ;* it has been mostly considered as only a sub-genus of *Lucina*. Also Stolickza, in his "Cretaceous Fossils of Southern India," quotes *Loripes* as a sub-genus of *Lucina*, but I think that the distinctive characters of the hinge of *Loripes* are so easily traceable, and so widely different from the characters of the other sub-genera of *Lucina*, that this group of forms is well worthy of a distinct generic designation, and thus Tate seems to be quite right when he considers *Loripes* as a well-distinguishable genus.

It is a somewhat surprising fact to find species of *Loripes* occurring in palæozoic strata, after the geological distribution as far as it has been known up to the present, seemed not to reach further back than the eocene formation. Nevertheless it can be most positively affirmed from the specimens from the Salt-range that the genus occurred already in palæozoic strata, as these specimens most clearly exhibit the characters of the hinge of *Loripes:* absence of lateral teeth, nearly obsolete cardinal teeth, and a ligament, which is entirely shut up in an internal

furrow of the hinge margin. There are two species of *Loripes* in the palæozoic strata of the Salt-range, which very likely are in a developmental connection with each other, one of them occurs in the middle, the other in the upper division of the Productus-limestone.

1. Loripes Atavus, Waagen, n. sp., Pl. XIX, figs. 1, 2.

The general form of this shell is nearly circular, with median beaks and moderately inflated valves.

The beaks are little prominent, pointed, and distinctly incurved towards the front. There is a small, not very deep, distinctly marked off, lunula in front of them, which has an elongated oval form. The anterior margin of the shell is slightly cut out as far as the lunula extends, but everywhere else the margins are perfectly rounded and continuous. The area, posteriorly to the beaks, is very small and narrow, as if cut in with a knife.

The surface of the shell is moderately arched, and covered by a very characteristic sculpture, consisting of very numerous fine concentric folds, which are little elevated and very close together.

The hinge of the left valve, which, only, could be made visible, consists of one very small, nearly obsolete cardinal tooth, in front of which there is a small, and behind a much larger, groove. Above the posterior groove there commences a deep and very distinct furrow, which extends along the arched posterior hinge margin and served for the insertion of the internal ligament. Every trace of lateral teeth is wanting. The interior margin of the shell is smooth; pallial and muscular impressions cannot be observed.

The substance of the shell is solid and tolerably thick. The dimensions of a specimen from Khúra, the largest known to me, are as follows:—

Entire length of the shell	10 mm.
Entire breadth „	9 „
Thickness of both valves	5 „
Apical angle	116°

Locality and geological position.—There are five specimens of this species in the Salt-range collection. One of them (duplicate) was collected by myself in the middle region of the upper division of the Productus-limestone at Khúra; two other specimens (left valves) were found by me at Katwáhi, also in the middle region of the upper division of the Productus-limestone, and one left valve was collected at Kufri (bed No. 14 of the section there) also by myself.

Remarks.—This very interesting little shell can be compared to several species occurring in upper palæozoic strata, but all of them described in other genera, having been mostly considered as belonging to the genus *Astarte*.

The shell which exhibits the greatest resemblance to the Indian fossil is *Astarte tunstallensis*, King, from the magnesian-limestone. It bears a similarly fine concentric striation, but its general form is more elongated and its beaks more

anterior. Of other species, *Astarte orbitosa* of Ryckholt might be compared, but its valves are more flattened, its general outline not so much orbicular, and the concentric striation not so fine.

As regards the hinge, the present species shows also some similarity to certain forms of *Scaldia;* but this similarity is only apparent, as in *Scaldia* there is no internal ligament, and the substance of the shell is very thin, as in *Cardiomorpha,* not solid, like in the present species.

2. Loripes proavius, Waagen, n. sp., Pl. XIX, fig. 3.

This is a very neat little species, which seems, however, to be very rare.

The general outline of the shell is more or less oval, higher than long. The valves are rather strongly inflated, with perfectly median beaks.

The breaks are tolerably prominent, not much pointed and little incurved. In front of them there is a not very deep but distinctly marked lunula of elongated oval shape, and posteriorly there seems to be a very small area, but covered up by rocky matter. The margins of the shell are all continuous, forming a somewhat orbicular outline.

The surface of the shell is very strongly arched, and covered by numerous concentric folds, which are not so numerous nor so fine as those of the preceding species. I count about twelve of them.

The hinge could not be well exposed.

The only specimen of this species exhibits the following dimensions :—

Entire length of the shell	5 mm.
Entire breadth „ „	6 „
Thickness of one valve	2 „
Apical angle	102°

Locality and geological position.—The only specimen of this species in the Salt-range collection is a left valve found by myself at Khúra, in a hard grey limestone at the top of the middle division of the Productus-limestone.

Remarks.—The generic position of this species has not been determined by the observation of the hinge, as was the case in the preceding one. The rock in which the shell is contained is too hard to admit of the characters of the hinge being exposed. This shell is, however, in every respect so similar to the preceding one, that I think there is but little doubt that it belongs to the same genus.

The present species can be distinguished from the preceding one by its more inflated valves, its shorter antero-posterior diameter, and the less fine concentric plication of its surface.

It is a fact worthy of notice that the two species, *Lor. proavius* and *L. atavus,* occur in successive strata in one and the same section at Khúra, the first having been found in the middle and the second in the upper division of the Productus-limestone. It is highly probable that the two stand in a developmental connection to each other.

Family: *ASTARTIDÆ.*

Sub-Family: *ASTARTINÆ.*

Genus: CARDINIA, Agass.

The only specimen that can possibly be attributed to Agassiz's genus is so very badly preserved, that it is only conjecturally that I place it in the genus *Cardinia.* Of the hinge there is nothing observable, and the substance of the shell has entirely disappeared, the specimen being thus formed of an external cast.

The occurrence of a species of *Cardinia* in the palæozoic strata of the Salt-range is not surprising. Already during devonian times the genus seems to have possessed a rather large development, which became even increased in the carboniferous period. From permian strata the genus has been quoted only in America. During the triassic period the genus seems to have been very rare in Europe, but in the lower lias it has a second maximum development, to be extinguished very soon after.

In general form the genus *Cardinia* has a great resemblance to *Anthracosia;* in fact, it is barely possible to distinguish the two genera if the hinge apparatus cannot be taken into consideration, and thus, in many cases it will remain doubtful whether one has to deal with a *Cardinia* or with an *Anthracosia.* The author of the genus *Anthracosia* very strongly insisted on its forming part of the *Unionidæ.* This view, however, has barely been accepted by any other writer, though the typical species of *Anthracosia* seem to occur in not quite typically marine strata, but in beds which have been deposited in more or less brackish water.

About the fully marine character of the palæozoic beds of the Salt-range, there can be, I think, not the slightest doubt, and thus I have preferred to place the shell I have to describe, in that genus which is undoubtedly marine. There is thus, I think, a greater probability of its being a *Cardinia* than an *Anthracosia,* though, it must be confessed, the latter might be the case.

In general form the Indian shell recalls very much the liassic species of *Cardinia,* with the sole exception that its hinge line is somewhat more curved, less straight. It resembles palæozoic species much less.

1. CARDINIA CONJUNGENS, Waagen n. sp., Pl. XVIII, fig. 11.

The only specimen of this species has an elongately oval form, with subanterior beaks, and a rather flattened surface.

The beaks are prominent, pointed, and not at all incurved. In front of them there is a very deep and strongly excavated lunula, which causes a deep sinuation of the anterior margin of the shell. The anterior part of the shell is narrow, strongly prominent, and on the whole well developed. Its margin forms a very narrow curve, and joins the ventral margin without the junction being anywhere

distinctly marked off. The ventral shell margin is very flatly arched, and passes directly into the posterior margin, which latter is not quite well preserved. There is, however, no doubt that the posterior part of the shell is much broader than the anterior one. The hinge line forms a flat arch, which ascends in an oblique direction from the posterior part of the shell to near the beak.

The shell is on the whole rather flat, as is generally the case in the genus *Cardinia;* but it cannot be observed whether it was very solid or not, as there is only an external cast of the shell.

The surface sculpture consists of concentric imbricating striæ of growth of very unequal strength, numerous, and close together near the ventral margin of the shell, and becoming more and more distant and indistinct towards the apex.

The measurements of the only specimen are as follows:—

Entire length of the shell, about	63 mm.
„ breadth „ „	36 „
Thickness of the left valve	10 „
Apical angle	?115°

Locality and geological position.—The specimen which has served for the description of this species was collected by Mr. Wynne in the trans-Indus continuation of the Salt-range at Gulámi, apparently in the lower division of the Productus-limestone. The label does not indicate the particular bed the specimen came from, but from the description of the section at Gulámi published in Wynne's report,[1] it appears that the only rock which agrees with the one in which the species is preserved occurs in his bed No. 3, immediately overlying his "Boulder Group."

The specimen is contained in a darkish yellow, very brittle sandstone which swarms with indistinct remains of Fucoids and fragments of the shells of *Spiriferæ.*

Remarks.—The specimen upon which this species is founded is too badly preserved to allow of any conclusions as to its relation to other similar forms. Species of *Cardinia* have already been described by Verchere from so-called carboniferous beds of India; but in his collection these specimens could not be found again. He mentions one *Cardinia himalayana*, Verch., and one *Cardinia ovalis*, Martin. The figures given of both are very bad,—so much, however, seems to be certain that the present species agrees with neither of them.

A species, which in general form is not dissimilar to the present one, is *Card. gigantea*, Quenst., from the lower lias of Württemberg. Though it generally grows much larger, yet it has a like narrowly-rounded and prominent anterior side, which gives it a great resemblance to our *Cardinia conjungens;* in this latter, however, the beaks are more prominent.

Of palæozoic species, *Cardinia vetusta*, A. Roem., from the devonian spirifer-sandstone of the Harz, might be compared. In general form this species is rather similar to the Indian *Card. conjungens;* but it attains a much less considerable size,

[1] Mem. Geol. Surv. Ind., Vol. XVII., p. 276.

and the posterior part of the shell is still shorter in comparison to the anterior one than is the case in the Indian shell. *Cardinia exilis*, M'Coy, from the carboniferous (?) formation of Australia is very likely a *Cardinia*, but bears only a distant resemblance to the present species.

Genus: ASTARTE, Sowerby.

It seems rather hazardous to quote this genus in a purely palæozoic fauna, as species of *Astarte* do not in general occur in strata lower than the mesozoic period; and there is the greater risk in that the internal characters of the shell I have to describe are not known. Nevertheless, it would be very difficult to state in what genus the shell here under consideration ought to be placed if it is not an *Astarte*, as in all external characters it resembles so closely several mesozoic species of the genus, that it is not easy to distinguish it, even specifically, from them. Yet it must be borne in mind that if I thus quote the genus *Astarte* as occurring in the strata of the Productus-limestone, this quotation means only an external similarity, and is not founded upon a careful examination of the internal characters.

De Ryckholt, in his "Mélanges Paléontologiques," has figured quite a number of palæozoic species of *Astarte*, but I regret to say he does not figure the hinge apparatus of any of them; and thus it is impossible to judge whether any of these shells really belong to the genus. We are in a better position with regard to *Astarte transversa*, Kon. Of the hinge of this species, Mons. de Koninck has given a very good enlarged figure, and according to it it seems very probable that we have to deal here really with a shell beloging to the genus. Thus it is fairly certain that the genus existed already during the carboniferous period. In permian times the genus was not very rare; and from this upwards we meet off and on species of *Astarte;* but only during the jurassic and cretaceous period did the genus reach its maximum of development.

In the Salt-range there is only one shell which can be considered as belonging to the genus.

1. Astarte Ambiensis, Waagen, n. sp., Pl. XIX, fig. 4.

The general form of this little shell is roundish, triangular, about as high as it is broad, with rather inflated valves, or but little excavated lunula, and a deep and sharply defined area.

The beaks are tolerably prominent, not much pointed, very little incurved, and very close together. In front of them there is a large, not very deeply excavated, but sharply defined lunula, which occupies nearly the entire anterior part of the shell. Where the lunula terminates the margin of the shell turns round in a very

narrow, almost angular, curve to meet the rather flatly arched ventral margin. The posterior margin forms an oblique flat curve, which joins the ventral margin obtusely. Behind the beaks there extends a deep and sharply defined triangular area, which forms a kind of fossa in which the external ligament was situated.

The valves are rather strongly inflated and covered by distant strong imbricating concentric folds, marking stages of growth. Between these there are fine striæ of growth.

The substance of the shell is solid.

The dimensions of the only specimen are as follows:—

Entire length of the shell	9·5 mm.
„ breadth „	9 „
Thickness of both valves	6 „
Apical angle, about	90°

Locality and geological position.—The single specimen of this species was collected by myself at Amb in a grey hard sandstone forming the top bed of the upper division of the Productus-limestone.

Remarks.—Though it cannot be asserted positively whether this shell really belongs to the genus *Astarte*, yet it seems highly probable that this is the case.

Several species of *Astarte* have been described, which might be compared to the shell here under consideration. Most similar seems to be *Astarte orbitosa*, Ryckh., from the carboniferous limestone of Visé. The surface sculpture of both shells is nearly identical, but the Indian fossil is much more inflated than Ryckholt's species, and thus can be easily distinguished from it.

Of more recent species, *Astarte antoni*, Giebel, from the Muschelkalk is not dissimilar to the present species, but can easily be distinguished by its more rounded, less triangular form.

Genus: GOULDIA, Adams.

Though all the species belonging to this genus are of very small dimensions, yet the general form of these shells and the characters of the hinge are so very characteristic, that they cannot easily be mistaken.

Nevertheless, these shells have been in general united with *Astarte*, as their minuteness very often makes it impossible to clear the hinge teeth from the rock.

I have been fortunate enough to succeed in exposing the hinge teeth of such a very small shell; and though the draftsman has not represented them very correctly, yet even from the figure it may be seen that the determination of this shell as a *Gouldia* is correct.

It is highly interesting to find this genus represented among the shells occurring in the thoroughly palæozoic strata of the Productus-limestone. Up to the present, species of *Gouldia* have hardly been observed to occur in strata older than jurassic; but this Salt-range species now carries the genus back into palæozoic times.

The jurassic and more recent species are generally gregarious shells, and though they are mostly but sparingly represented, yet, in places where they occur, numbers of them may be found. This is, however, not the case with the species from the Salt-range. It is a very rare shell, and nowhere has a number of individuals been observed together; only at one place two solitary valves of the species have been detected.

1. GOULDIA PRIMÆVA, Waagen, n. sp., Pl. XIX, fig. 5.

The general form of this little shell is nearly circular, only slightly excavated in front of the beaks, where the lunula is situated. The valves are not very strongly inflated, and are covered by very coarse broad folds.

The beaks are small, little prominent, pointed, but little incurved, and, as it seems, nearly continuous. In front of them there is a small, but deeply excavated and sharply defined lunula. The margins of the shell are all continuous, and it is barely possible to distinguish between anterior, ventral and posterior margins, all joining to form one nearly circular outline. Posteriorly to the beaks there is a narrow but sharply defined triangular area. It is not possible to distinguish the length of the ligament, but it was certainly external.

The hinge is only observable in the left valve. It consists of two cardinal teeth, of not quite equal strength, the posterior one being somewhat larger. There may have been an anterior lateral tooth, but this cannot be made out with certainty.

The substance of the shell is very solid. The interior shell margin seems to have been smooth, but it has been weathered in such a peculiar way that irregular crenulations have been formed, of which it is barely possible to say whether they existed originally or not.

The surface sculpture of the shell is very characteristic. It consists of about six very broad and high, roof shaped, concentric folds, with narrow valleys between them. These folds cover the whole surface of the shell except the lunula and hinge area, where they stop on the angular ridge surrounding both these parts of the shell.

The shell is rather flat, not much inflated.

The dimensions of a specimen from Virgal are as follows:—

Entire length of the shell	5·5 mm.
„ breadth „	5 „
Thickness of the left valve	2 „
Apical angle	113°

Locality and geological position.—The type specimen of this species was collected by myself at Virgal, in a bed of white sandstone forming the topmost layer of the upper division of the Productus-limestone. Another specimen, somewhat larger, 7 mm. in length, the specific identity of which is, however, somewhat doubtful, was found by myself at the same locality and in the same bed as the preceding one.

Remarks.—As species of *Gouldia* have up to the present not been quoted in palæozoic strata, it is necessary to look out in other genera for shells which might be compared with the present species. There is principally the genus *Astarte*, in which similar species might occur, and in fact there have been figured by Geinitz from Nebrasca two species of *Astarte* which are not dissimilar to the present species. They are *Astarte nebrascensis*, Gein., and *astarte sp. ind.* (pl. I., fig. 27, Gein. Foss. from Nebrasca). The distant concentric ribs on these shells are somewhat similar to those exhibited by our *Gouldia primæva*, but Meek, in his final report on Nebrasca, states that these species have no distinct and sharply defined lunula, and that the substance of their shells is very thin, so that both are very likely *Edmondia* or *Cardiomorpha*, not *Astarte;* and thus they cannot be compared to the present shell.

Of other palæozoic species, as far as is known to me, none can be compared.

The mesozoic species are generally more triangular than the present species; some, however, seem to be very similar to it.

Sub-family: *CARDITINÆ.*

Genus: PLEUROPHORUS, King.

This genus is one which has already very often been the subject of controversy, and even the beautiful drawing of the hinge given in King's monograph of the permian fossils has been considered as purely a product of phantasy. Nevertheless, I think the genus stands quite sound, and comprises a very characteristic series of forms which are well worth a proper generic designation.

Regarding the characters of the genus it appears that the definition of it, as proposed by King, can in every respect be maintained; but, of course, these characters must not be changed and contested in an arbitrary manner if one wishes to retain the genus.

The shells belonging to *Pleurophorus* are equivalve, very elongately inequilateral, with anterior beaks, closed all round. The substance of the shell is solid, and bears a surface sculpture consisting either only of concentric folds, or also partly of radiating costæ. In front of the beaks there is a more or less distinct lunula. The ligament is external, not very long and supported by distinct fulcra. The hinge consists of two cardinal teeth in each valve, of which in the right valve the anterior and in the left valve the posterior are often very small. A more or less strongly developed very elongated posterior lateral tooth is present. The pallial line is entire; the posterior muscular impression is very large and generally not very deep; the anterior one is not so large but very deep and surrounded posteriorly by a strong ridge, which descends interiorly from near the beak to the ventral margin of the shell.

Of these characters those relating to the hinge teeth have been very often

doubted. M'Coy, in his British Palæozoic Fossils, even denies their existence entirely or admits only traces of them to be present; and Seebach, supported by observations made on some species from the Muschelkalk, again says that only one cardinal tooth is developed. The former author accordingly unites the genus *Pleurophorus* with *Clidophorus*, Hall, whilst the latter considers the same as identical with *Myoconcha*, Sow.

It can, I think, not be doubted that the three genera—*Clidophorus*, *Pleurophorus* and *Myoconcha*—are very similar to each other, and that it is chiefly a greater or less development of the cardinal teeth which furnished the chief characters for the distinction of them; nevertheless, the distinction once made should be retained, as very natural groups of forms are marked off by them, which exhibit also a peculiar geological distribution. In the palæozoic formations the forms which are distinguished as *Clidophorus*, without cardinal teeth but with a more or less developed posterior lateral tooth, and those belonging to *Pleurophorus* proper, are represented. The former commence already in the silurian period and seem to reach up into the trias; the latter, however, seem to have their first representatives in devonian strata, show their chief development during carboniferous and permian times, and seem to disappear in triassic strata.

It is now very interesting to observe how in the trias the genus *Pleurophorus* apparently slowly changes into *Myoconcha*. *Myoconcha thielaui*, Stromb., of the Muschelkalk (if the observation be correct, which may fairly be doubted), has sometimes two, sometimes only one cardinal tooth, in which latter case its similarity to *Myoconcha* is obvious.[1] It cannot be denied that also in the palæozoic *Pleurophorus* one of the two cardinal teeth is often very little developed; and if the rock in which such a shell is preserved is in some degree hard, it very easily happens that in clearing the hinge from the rock, this small tooth is lost, so that the hinge would appear to possess only one cardinal tooth; but in well preserved specimens a second cardinal tooth will always be present.

Another difference between *Myoconcha* and *Pleurophorus* consists in the ligament, which is very long in the former and rather short in the latter genus.

And lastly, the general form of the shells belonging to the two genera is rather different. In *Pleurophorus* this is rather rectangular, the beaks being anterior but not terminal; in *Myoconcha*, on the contrary, the beaks are nearly quite terminal, and thus the general form of the shell becomes more or less MYTILOID.

The close relation in which the three genera, *Clidophorus*, *Pleurophorus*, and *Myoconcha* stand to each other is a vivid illustration of what difficulties a classification of the *Pelecypoda* has to encounter. The genus *Clidophorus* was first mentioned by Stoliczka in the family *Pharellidæ;* then he transferred it to the *Solemyidæ*, and at last he again left its position undecided. In regard to *Pleurophorus*, most authors are in accordance as to its position in the *Carditinæ;* but

[1] See the figures by Seebach; Zeitschr. Deutsch. Geolog. Ges., Vol. XIII., 1861, pl. XV., fig. 2 and Schauroth: Sitzgsber. Acad. Wiss. Wien., Vol. XVII, 1855, pl. II, fig. 4.

Myoconcha has been placed by some authors in the *Carditinæ*, by others in the *Prasinæ* of the *Mytilacea*.

There is, I think, but little doubt that *Clidophorus* must be placed somewhere near *Pleurophorus*, and has to be considered, so to say, as a *Pleurophorus*, in which the cardinal teeth have become obsolete. *Myoconcha*, on the contrary, may perhaps more correctly be placed in the *Mytilacea*, as the similarity of this genus to *Pleurophorus* seems to be only superficial. A much closer relation than between *Pleurophorus* and *Myoconcha* seems to exist between the latter genus and *Modiomorpha* of Hall, which is very likely the ancestor of *Myoconcha*. *Modiomorpha* is not only largely represented in the devonian strata of America, but also in Europe it seems to occur in beds of similar age; at least *Myoconcha compressa* of Roemer is something very like *Modiomorpha*.

In the palæozoic deposits of the Salt-range not less than four species of *Pleurophorus* occur. Among these most of the known generic types are represented; only one, that typified by *Pleur. costatus*, Brown, is absent in the Salt-range. There can very conveniently be distinguished three sections, according to the three different types. The first of these types exhibits a smooth shell, which bears only a concentric, little prominent sculpture. I shall introduce the name of *Imbricati* for this section. A second type has more or less strongly developed costæ on the posterior part of the shell, and therefore will form the section of the *Costati;* a third type bears very strongly radical plications on the posterior part of its shell, and thus will bear the name *Plicati*. The Salt-range species will thus be grouped in the following way:—

I Section: Imbricati—
1. *Pleurophorus imbricatus*, Kon., sp.
2. „ *subovalis*, Waagen n. sp.
3. „ *complanatus*, Waagen n. sp.

II Section: Costati.
Not represented in the Salt-range.

III Section: Plicati.
4. *Pleurophorus acuteplicatus*, Waagen n. sp.

The first section of the genus, the *Imbricati*, may possibly already commence in the devonian period. In the carboniferous it seems to be represented by species like *Cardinia phaseolus*, Sow, but on the whole it appears not to be common during that formation. In Australia *Pleur. carinatus*, Morr. (a name which cannot stand if Roemer's *Cardinia carinata* is really a *Pleurophorus*), might belong to the section if it is a *Pleurophorus* at all. In beds corresponding to the permian formation the representation of this section of the genus is somewhat doubtful, if *Pleurophorus ovatus*, King, should possibly not be considered as such. There is on the whole no doubt that this section attains its greatest development in the Productus-limestone of the Salt-range. Of the three species occurring there *Pleur. subovalis*, W, is geologically the oldest; next in succession comes *Pleur. imbri-*

catus, Kon sp., and the most recent is *Pleur. complanatus*, W. There is but little doubt that all three stand in developmental connection and constitute one series of forms which may best be designated as the group of *Pleur. subovalis*, W.

The second section, the *Costati*, can with tolerable certainty be traced back to the devonian period. A. Roemer has described from the spirifer-sandstone of the Harz a species which he calls *Cardinia carinata*. The hinge of the right valve, which he figures, exhibits two very distinct cardinal teeth, as in *Pleurophorus*, and not one only, as in *Cardinia*. Though the posterior lateral tooth, which is generally present in *Pleurophorus*, seems to be absent in Roemer's species, yet the general form of the shell and its characteristic sculpture leave but very little doubt that we have to deal here with a *Pleurophorus*.

A shell very nearly related to the one mentioned above is *Cypricardia striato-lamellosa*, Kon., from the carboniferous limestone of Visé. Already King has suggested that this shell was very likely a *Pleurophorus*, and since that time several writers have expressed themselves in favour of that opinion. *Cardinia carinata*, R., and *Cypricardia striato-lamellosa*, K., are nearly identical in form, and there was very likely a developmental connection between the two. Whether *Pleur. costatus*, Brown, the most common species of the permian formation, is also a member of the same developmental series, remains doubtful. Also in America there are species belonging to the section of the *Costati*, for instance, *Pleur. occidentalis*, M. and H., from the permo-carboniferous formation of Nebrasca, or *Pleur. costatiformis*, M. and W., from the Keokuk limestone. In the Salt-range the section has not been detected up to the present.

The third section, as far as is known to me, has up to the present not been observed in Europe. One species, very likely belonging to this section, has been described by Morris as *Orthonota costata*, which name was afterwards changed by L. G. de Koninck into *Pleur. morrisi*. It was found in the carboniferous (?) beds of Illawara and Wollongong in Australia. Another species from the latter locality, which has been called by Koninck *Pleur. biplex*, is very likely a *Grammysia*. The section is represented in the Salt-range by a single species, *Pleur. acuteplicatus*, W., which stands in no connection whatever to *Pleur. morrisi*.

Section I: IMBRICATI.

Group of Pleurophorus subovalis, *Waagen.*

1. Pleurophorus imbricatus, Koninck, sp., Pl. XVIII, fig. 1.

1863. Solenopsis imbricata, Koninck, Quart. Journ. Geol. Soc., Lond., Vol. XIX, p. 8, pl. IV, fig. 3.
1863. Solenopsis imbricata, Koninck, Fossiles Paléozoiques de l'Indc, p. 16, pl. III, fig. 3.

The general form of the shell is elongated trapezoidal, with nearly parallel margins, dorsal and ventral. The shell is equivalve, very unsymmetrical, with subanterior beaks.

The beaks are very small, very little prominent, pointed, and barely at all incurved. In front of them there is a small, deep and distinctly defined lunula of narrowly oval shape. The anterior part of the shell is very short and little prominent, its margin forming a narrowly rounded curve. The ventral margin of the shell is slightly concave, and joins the posterior margin in an obtuse angle. Posteriorly the shell is somewhat truncated, the margin there going up in a nearly straight line of somewhat oblique direction. It joins the dorsal margin without forming a distinct angle. Posteriorly to the beaks there is a deeply excavated hinge area, in the depth of which the ligament is situated.

From the beak to the ventral margin there extends a broad shallow depression, whilst posteriorly a triangular space is marked off by an obtuse ridge extending from the beak to the lower posterior corner of the shell.

The whole surface of the shell is covered by strong imbricating concentric folds, parallel to the shell margins, marking stages of growth. Between these folds barely any finer striæ of growth are visible.

The substance of the shell is very solid. The hinge cannot be observed.

The valves are very flat and depressed.

The measurements of the larger specimen are as follows:—

Entire length of the shell	43 mm.
„ breadth „	17 „
Thickness of the right valve	7·5 „
Apical angle	130°

Locality and geological position.—The typical specimen of this species (a right valve) was collected by Dr. Fleming at Vurcha, and is preserved in the collection of the Geological Society of London.

This specimen is contained in a dark yellow oolitic marly rock containing a number of fragments of other fossils; and I think it highly probable that the specimen came from the middle region of the upper division of the Productus-limestone.

Another smaller specimen (left valve), also very probably belonging to this species, was collected by myself at Katwáhi in a grey friable sandstone, belonging to the middle region of the upper division of the Productus-limestone.

Remarks.—As this species was originally described by Mons. de Koninck in the genus *Solenopsis*, it requires some words of explanation why I have transferred it to *Pleurophorus*.

In *Solenopsis* the shell is very transversely elongate, apparently not very solid, and is distinctly gaping posteriorly. In these latter two points the present species differs distinctly from M'Coy's genus, as it possesses a very solid shell, which is closed all round and nowhere gaping.

The internal characters could not be observed in the present species, but in its external appearance it so closely resembles the two following species, which possess an entire pallial impression and two distinct cardinal teeth, that the genus *Pleurophorus* is also the most probable one for the shell here under consideration.

The genus *Solenopsis* seems not to have been quite correctly interpreted by de Ryckholt, and thus some of his species of *Solenopsis* might very well be considered as *Pleurophorus*. Thus very likely *Solenopsis uniplicata*, Ryckh., is a *Pleurophorus;* and it bears a certain resemblance to *Pleurophorus imbricatus*, but can easily be distinguished by its more unsymmetrical form and the greater inflation of its valves.

I know of no other species which could at all be compared to *Pleurophorus imbricatus*.

2. PLEUROPHORUS SUBOVALIS, Waagen, n. sp., Pl. XVIII, figs. 2, 3.

The general form of this species is very elongately oval, rounded in front and obliquely truncate behind.

The beaks are sub-anterior, very little prominent, pointed and barely incurved. In front of them there is a very small indistinct lunula which causes barely any sinuation in the outline of the shell.

The anterior shell margin is broadly rounded, and not limited off from the ventral margin, which is flatly arched. At the junction between the ventral and posterior margins of the shell an obtuse angle is formed. The posterior margin is nearly straight, and goes obliquely up to the hinge line, joining it at an obtuse angle. Posteriorly to the beaks there extends along the straight hinge line a very narrow, but very distinct area. The length and mode of insertion of the ligament cannot be observed.

The hinge cannot be well observed in any of the specimens at my disposal; a posterior lateral tooth is apparently visible in one specimen, but of the cardinal teeth nothing can be seen.

On an internal cast from Khúra the pallial line and posterior muscular impression are very well visible; the former is most strongly marked, and runs nearly for its entire length parallel to the ventral margin of the shell. Posteriorly it suddenly bends up and joins the very large and very deep impression of the posterior adductor at its posterior end. This latter impression is of very shortly oval, nearly circular shape. In front and superiorly to it there seems to be a second smaller muscular impression, which is, however, not so distinct as it has been figured (pl. XVIII, fig. 3) by the draughtsman. The anterior muscular impression is covered up by rocky matter.

Externally the sculpturing of the shell is very characteristic. From the beaks to the lower posterior corner of the shell there extends a very indistinct obtuse ridge, marking off a triangular posterior space on the shell. There is however, unlike in the preceding species, a depression of the shell extending from the beak to the ventral margin; but the surface of the shell is very regularly arched, not much inflated. The whole shell is covered by concentric sculpturing of two different kinds. There are a few strong concentric imbricating folds, marking stages of growth, whilst between them a distinct fine concentric striation occurs.

The measurements of a specimen from Chidru are as follows :—

Entire length of the shell, about	44 mm.
„ breadth „	18 „
Thickness of the left valve	8 „
Apical angle	150°

Locality and geological position.—There are two specimens of this species preserved in the Salt-range collection. One, an internal cast of the left valve, was found by myself at Khúra in very hard compact limestone, at the upper limit of the middle division of the Productus-limestone; another, also a left valve, but provided with its shell, comes from Chidru, and was found there by me in a hard somewhat oolitic limestone in the lower beds of the upper division of the Productus-limestone.

The species thus seems to range from the middle to the upper Productus-limestone, and so would be anterior in its geological age to the species described before as *Pleurophorus imbricatus*, which latter has up to the present been detected only in the upper division of the same formation.

Remarks.—The present species in its general form very much resembles *Pleurophorus imbricatus*, Kon., and might easily be mistaken for that species, but on closer comparison very characteristic differences can be detected.

Chiefly, the general outline of the present species is much more oval and less trapezoidal than in *Pleurophorus imbricatus;* the ventral margin of the shell is arched instead of being excavated, and there is no depression extending from the beak to the ventral margin; the sculpture is less strongly marked, and between the imbricating folds fine striæ of growth are intercalated; lastly, the apical angle is much greater in this than in the preceding species.

Of European fossils only *Solenopsis omalii*, Ryckh. might be compared, but this shell has a much narrower posterior part, not to speak of the different sculpture.

In America a species which is very nearly related to the shell described above as *Pleurophorus subovalis*, has been erroneously figured by Meek and Worthen (Illinois Reports, Vol. III, pl. 19, fig. 5), under the name of *Pleurophorus costatiformis*, M. and W.: although it is stated in the text that this figure represents a species different from *Pleurophorus costatiformis*, yet there is no proper name given for it. The specimen was found in the Keokuk-limestone, lower carboniferous. This shell also can be distinguished from the Indian species, as it is somewhat broader in comparison to its length and has a narrower posterior end.

3. Pleurophorus complanatus, Waagen, n. sp., Pl. XVIII, figs. 5—7.

This is a much smaller species than the two described above.

The general form of this species is not very long, trapezoidal, with parallel dorsal and ventral margins. It is very inequilateral, the apex being nearly terminal

in its position, obliquely truncated behind and rounded in front. The valves are very strongly compressed and flat.

The apex is very small, not at all prominent and not incurved. In front of it there is a very narrow, small, distinct but not sharply defined lunula, which causes a sinuation in the outline of the shell.

The anterior shell margin is tolerably broadly rounded and joins the ventral margin without distinct limitation. The latter is straight or very slightly sinuated, and forms an obtuse angle where it unites with the posterior margin of the shell. This latter is very slightly arched and ascends in an oblique direction to meet the straight hinge line under a broadly obtuse angle. Posteriorly to the beaks there is a not very long but distinct narrow area.

The ligament is short, situated immediately behind the beaks and supported by fulcra.

The hinge of the right valve, which is alone known to me, consists of two distinct cardinal teeth, of which the anterior one is very small, and easily lost in clearing the hinge of the adhering rock; the posterior tooth is very large and somewhat inclined, separated from the anterior by a broad and deep groove for the reception of a large tooth of the left valve. Posteriorly to this large cardinal tooth there is a smaller triangular groove for the reception of the posterior cardinal tooth of the left valve. Behind this groove follows a flat space which supports the fulcrum for the insertion of the ligament.

A short way behind the cardinal hinge apparatus a posterior lateral tooth commences as a thin shelly ridge, increasing in size further behind, and situated parallel to the long straight posterior hinge margin. It seems to extend nearly the whole length.

Pallial and muscular impressions are not visible.

The surface sculpture of the shell is very simple. From the beak to the lower posterior corner there extends a very obtuse and low, barely perceptible, angular elevation, which marks off a posterior triangular space of the shell. A very flat depression, extending from the beak to the ventral margin, is sometimes perceptible, sometimes no trace of it exists. The surface of the shell is covered by very numerous fine striæ of growth, which are at very irregular intervals interrupted by strong concentric imbricating folds, which are however never very numerous, hardly in any case showing a greater number than three.

The measurements of a specimen from Virgal are as follows:—

Entire length of the shell	19 mm.
„ breadth „	9 „
Thickness of the right valve	2 „
Apical angle	117°

The species seems not to grow much larger than the specimen of which the measurements have been given, as among eight specimens no larger ones occur.

Locality and geological position.—This species is not at all rare in the top-

most beds of the upper division of the Productus-limestone. It has been collected in these beds by myself at Virgal (three specimens, one right and two left valves) and at Chidru (five specimens, one right and four left valves).

Remarks.—This species is subject to slight variations, which are however easily to be recognised as such. For instance, one of the left valves from Virgal has the dorsal and ventral margins not so parallel as in the figured specimen, and in consequence of this the posterior part of the shell is narrower, but in all other respects it agrees perfectly with the typical form. A great variability exists also in respect to the number and distance of the larger imbricating folds, of which sometimes only one is present instead of three or four as in other specimens.

Of species hitherto described *Pleur. imbricatus,* Kon., is the most nearly related to the present form, and chiefly in the earlier stages of growth the two shells can only with difficulty be distinguished. Nevertheless the smaller specimens show some characteristic differences. *Pleur. imbricatus* is in all stages of growth more elongated in its general outline, and its valves are more inflated. The depression of the shell, which extends from the beak to the ventral margin, is more strongly developed, and the strong imbricating folds are more numerous.

Also *Pleur. subovalis,* W., is rather nearly related to the species here under consideration, but its arched ventral margin, greater elongation, and the considerable inflation of its valves make also here a distinction not too difficult.

A very noteworthy fact is the relative position of the beaks of the valves in the three species. In *Pleur. subovalis,* W., which is geologically the oldest of the three, the beaks are most nearly approached to the middle of the shell, though also here the general form of the shell is very unsymmetrical. The beak is very little prominent, and thus its position chiefly determines the expansion of the apical angle, which in this species is as much as 150 degrees. In *Pleur. imbricatus,* which is next younger in geological succession, the beaks of the valves are more anterior, and thus, under otherwise similar circumstances, the apical angle decreases and has only an expansion of 130 degrees. Lastly, in *Pleur. complanatus,* W., the geologically youngest species of the three, the beaks are yet more anterior in their position, and thus the apical angle again decreases to a considerable extent, its width being, however, not quite constant. In those specimens in which the beaks are most anterior, this angle is about 110 degrees; in other specimens it is as much as 117° yet considerably smaller than in *Pleur. imbricatus.* Thus in the three species, which are in continuous geological succession, a very marked tendency to change in a certain distinct direction is traceable, consisting in a constant decrease of the apical angle. This, however, goes hand in hand with another peculiarity, a constant decrease in the inflation of the valves which become more and more flat in the more recent species.

Thus the three species *Pleur. subovalis,* W., *Pleur. imbricatus,* Kon., and *Pleur. complanatus,* W., can fairly be considered as constituting a developmental series.

Of American species, one or the other might be compared to *Pleur. complanatus*, but I do not think that any of them is identical.

Also the shell, which has been figured by Benecke (Geognost. Pal. Beitr. II, Pl. 3, fig. 3) under the name of *Myoconcha gasterochæna*, Dunk., bears a great resemblance to our *Pleur. complanatus*.

Section III: PLICATI.

4. Pleurophorus acuteplicatus, Waagen, n. sp., Pl. XVIII, fig. 10.

The general form of this shell is not much like that of a *Pleurophorus*, but recalls much more that of *Cardita*, although from that genus also it differs more or less widely.

This species is in its general form more or less shortly trapezoidal, with tolerably parallel dorsal and ventral margins. The beaks are very much anterior and therefore the form of the valves very unsymmetrical. The valves are tolerably strongly inflated and closed all round.

The beaks are very small, pointed and not much incurved, very close together, and very little prominent. In front of the beaks there is a small deeply excavated but not very distinctly defined lunula, quite sunk in so as not to show in the outline of the shell. The anterior shell margin is obliquely truncated, nearly straight. It joins the ventral margin in first forming an obtuse angle, and then descending in an oblique direction. The ventral margin of the shell is nearly straight for a short distance, and then rises to meet the posterior margin which ascends in an oblique line until it reaches the hinge area, where it forms a distinct obtuse angle.

The hinge line is nearly quite straight. Behind the beaks there is a sharply defined not very broad hinge area on each valve, and in the fossa formed by the areas of the two valves there extends a not very long ligament distinctly external, and apparently, as far as can be seen from the smallness of the shell, supported by fulcra.

The characters of the hinge itself cannot be observed.

The sculpture is very characteristic, dividing the shell into two parts. Anteriorly there is a faint concentric sulcation observable, parallel to the ventral margin of the shell, but posteriorly there extend five or six high sharp radiating folds, taking their origin at the beaks, and they also are crossed by a fine concentric striation. They alternate on the two valves and thus cause the ventral margin to form a broken line. The plicated part of the shell is, however, much larger than the smooth part, occupying about two-thirds of the whole length of the shell. The first radial fold, which is situated most anteriorly, descends from the beak in an oblique line and meets the ventral margin a little anteriorly to its middle. All the following folds have a more and more oblique direction; the third meets the lower

posterior angle of the shell, and the sixth or fifth is nearly parallel to the hinge margin. As the folds alternate their number is not equal on the two valves; there are five on the left and six on the right valve.

The substance of the shell is rather solid.

Muscular and pallial impressions are not visible.

The measurements of the only specimen are as follows:—

Entire length of the shell, about	9 mm.
„ breadth „ „	6 „
Thickness of both valves	3·5 „
Apical angle	120°

Locality and geological position.—The only specimen of this species preserved in the Salt-range collection was found by myself in the top beds of the upper division of the Productus-limestone at Virgal. It represents an individual which retains both valves, but is somewhat broken at its posterior end.

Remarks.—The position of this shell in the genus *Pleurophorus* is not beyond every doubt, as it has been impossible to make the characters of the hinge visible. The solidity of its shell and its general form indicate, however, this position as the most probable one, otherwise it could only be the representative of a new genus intermediate between *Pleurophorus* and *Palœocardita*.

The general form and sculpture of this shell are so very peculiar that it can hardly be compared to any species hitherto described. From Australia a species has been made known as *Pleurophorus morrisi*, Kon., which has at least the posterior part of the shell plicated to a certain extent, but the folds are very much more numerous and more limited to the posterior part of the shell than is the case in the present species.

Much more similar, though also only distantly related, is a species which has been described most recently by Noetling from the Muschelkalk of lower Silesia, and which has been called by him *Myoconcha beyrichi*.

The hinge of this species has not been figured, and from the description alone it is not easy to judge; but Noetling speaks of two cardinal teeth in the right valve, and thus this shell might well be a *Pleurophorus*. The similarity of this shell to the Indian species consists chiefly in its posterior part being strongly costate, and the smooth anterior part being very small, otherwise but little accordance exists between the two.

Thus *Pleurophorus acuteplicatus*, W., seems to be rather isolated, and its true relation to other forms can only be made out in the future.

Genus: CLEIDOPHORUS, Hall.

Already in the introductory remarks to the preceding genus I had several times occasion to mention the genus *Cleidophorus*. As to the mode of writing this name, it seems to me of no great importance whether the strict spelling

"*Cleidophorus*" or the spelling "*Clidophorus*," according to the New-greek pronunciation of the "*ei*," be adopted. In order to satisfy purists, who possibly might object to the second mode of spelling, I have used the first one in the heading, but otherwise I am of opinion that either spelling may be optionally used.

Cleidophorus, as was mentioned a few pages before, seems to be in very near relation to *Pleurophorus*, though this relation has not been acknowledged by all palæontologists. Dr. Stoliczka's view that the genus formed part of the family *Solemyidæ* whilst *Pleurophorus* belonged to the *Astartidæ* will, I think, be accepted by only a very few men of science; most of them will rather follow the other opinion, that *Cleidophorus* was a sub-genus of *Pleurophorus*. Also Hall himself, in his most recent classification of the Lamellibranchiate shells, adopted in Miller's catalogue, puts *Cleidophorus* and *Pleurophorus* into one and the same family, which he calls *Cyprinidæ*.

A great many authors, however, among them M'Coy and Woodward, not only wish to unite both genera in one and the same family, but they even consider the two genera as identical, and the former writer therefore suppresses the name *Pleurophorus* entirely. That this should not be done, I have already intimated in the introductory notes on the latter genus. It remains yet to be shown that *Clidophorus* may well be retained as a proper genus.

To begin with, it is very difficult to find out if the shells which are generally considered as *Clidophorus*, chiefly the permian species, are really generically identical with the form which was originally called by Hall *Cleidophorus*. In order to settle this question it would be necessary to examine the typical species from American silurian rocks, a precaution which is impossible for me for want of material. In America, according to Miller's catalogue, the genus *Cleidophorus* is quoted only from silurian and devonian strata, whilst the carboniferous and permian species are referred to the genus *Pleurophorus*.

According to Hall's description *Clidophorus* is very thinly shelled, perfectly edentulous and provided with an internal ridge, surrounding the anterior muscular impression. The more recent species which have been subsumed in the genus are not always perfectly edentulous, but in many cases an elongated posterior lateral tooth has been observed, being in its position parallel to the posterior hinge margin. Nevertheless, I think these shells may be united with *Cleidophorus*, as every intermediate form occurs, between the perfectly edentulous and those with a slightly developed posterior lateral tooth.

We can thus define the genus *Clidophorus* in the following manner:— Equivalve, very inequilateral, with sub-anterior beaks; substance of the shell very thin, surface smooth, only with concentric striæ or with fine radiating costæ; hinge without cardinal teeth, sometimes with one elongated posterior lateral tooth; ligament external, not very long, sometimes supported by fulcra; pallial impression simple; posterior muscular impression large, but very faint; anterior one much smaller, but very deep, surrounded posteriorly by a stong prominent ridge, which

descends from within the beak to near the ventral margin. In the internal cast this ridge produces a deep incision just in front of the beak.

The genus *Cleidophorus* commences already in lower silurian strata, is not rare in the upper silurian, but seems not to be represented very numerously in the devonian formation, though many species belonging to it may have been described under the name of *Nucula*. During lower carboniferous times the genus had not entirely died out, but species are very few, reduced in number to two or three, whilst in the coal-measures the genus attains suddenly a considerable development, which it seems to possess also during the permian formation. In the trias the genus is still represented, though it is very difficult to state how numerous the species may have been, as most of the species have been assigned to other genera. So much is certain that in jurassic strata no representative of the genus any longer exists.

The species belonging to this genus are formed according to two different types, which may very well serve for the distinction of two sections within the genus. The first is typified by *Modiola simpla*, Keys., *Clidophorus simplus*, Gein. It comprises shells of more or less trapezoidal outline and only concentric sculpture; this section may conveniently be called the *Simplices*. The other type is represented by *Modiola pallasi*, Vern., *Clidophorus pallasi*, Gein. The shells belonging to this type are more Modioliform, with nearly terminal beaks and very little developed anterior part of the shell. In well-preserved specimens the surface is mostly finely striated, radiately; the name of *Modioliformis* may be used for this section.

The first section seems to be represented already among the silurian species; it is also not rare in the American coal-measures. The second section on the contrary has apparently its oldest representatives in the carboniferous period, and is most numerously developed during permian times, extending into triassic strata.

In the Salt-range Productus-limestone both these sections are represented, each by one species, and thus we have—

Section I: Simplices.
1. *Cleidophorus trapezoidalis*, W.

Section II: Modioliformes.
2. *Cleidophorus striatulus*, W.

It is not possible to indicate any species with which either of the Indian shells could be in close connection. The first is related to *Clid. simplus*, Keys., sp.; the second to *Clid. pallasi*, Vern., sp., without showing, however, a striking similarity.

The genus *Pleurophorus* seems to have branched off from the geologically older *Clidophorus* during lower devonian times in developing cardinal teeth and a posterior lateral one, which latter character appears also in the newer species of *Clidophorus*; on the other hand, *Pleurophorus* seems again to be the ancestor of *Palæocardita*. Such a developmental connection can, however, here only be hinted at; we are yet far from being able to prove such a connection by striking facts.

Section I: SIMPLICES.

2. Cleidophorus trapezoidalis, Waagen, n. sp., Pl. XVIII, fig. 4.

The general form of this species is elongated trapezoidal, somewhat broader on its posterior than on its anterior part. The shell is very inequilateral and tolerably inflated.

The beaks are very little prominent, rounded and not much incurved. In front of them a very small, tolerably deep, roundish lunula is situated, which is, however, not sharply defined and causes no deep sinuation in the outline of the shell. The anterior margin of the shell projects but little in front of the beaks, and forms a tolerably broad arch. The ventral margin joins the anterior one without a marked limit, is sinuated in its anterior part, and then descends in a nearly straight oblique line to the lower posterior corner of the shell. This corner is, however, not angular, but rather broadly rounded. From there the posterior margin ascends straight, in a very slightly oblique direction, and joins the hinge line by a rounded off corner. The hinge line is very flatly arched, nearly quite straight, and the area, which is generally present along this part of the shell, is so narrow that it seems reduced to a mere line.

The mode of insertion of the ligament cannot be observed.

The hinge itself is preserved only in the impression on the rock. As far as it can be judged from this impression, there were no cardinal teeth, but posteriorly to the beaks and parallel to the hinge line, there extended a poorly developed, long, narrow, more or less lamellar, posterior lateral tooth.

Immediately in front of the beak there is a very strong and high internal ridge, which descends vertically to near the ventral margin, without, however, reaching it. On the cast this ridge appears as a deep and narrow incision just in front of the beak.

Muscular and pallial impressions cannot be observed.

The substance of the shell was very thin.

The valves are tolerably strongly inflated, and are thickest about in the middle of their length. There extends from the beaks to the ventral margin of the shell, in an oblique direction, a broad flat depression which produces a sinuation of the ventral margin.

The surface of the shell is covered by not numerous, rather strong, concentric imbricating folds, marking stages of growth.

The dimensions of the only specimen are as follows:—

Entire length of the shell, about	50 mm.
„ breadth „ anteriorly	18 „
„ „ „ posteriorly	23 „
Thickness of the left valve	11 „
Apical angle, about	130°

Locality and geological position.—The only specimen of this species preserved in the Salt-range collection was detected by myself near Katwáhi, on the road to Shahpur, in a very friable yellowish grey sandstone in the middle region of the upper division of the Productus-limestone. The specimen consists in an internal cast of a rather large individual, with parts of the shell adhering to the left valve.

Remarks.—There is chiefly one species, which has been described by Meek and Hayden from the "Coal-measures" of Nebrasca, very similar to the present one; this is *Pleurophorus oblongus*, M. and H. That this species is not a *Pleurophorus* but a *Cleidophorus* is already evident from its very thin shell, as also from the long, slender posterior lateral tooth, which is indicated as the only existing tooth. In general form this species is very similar to our *Cleid. trapezoidalis;* but besides that it has a much less considerable size, its anterior part is also much narrower, and its posterior much broader than in the Indian shell.

Cleidophorus simplus, Keys., sp., is much less nearly related, as in that species the posterior part is narrower than the anterior one; nevertheless, there exists a certain similarity of type between the two shells.

On the whole, one can say that the relation of the present species lies much more with permian and upper coal-measures species than with shells from truly carboniferous rocks.

Section II: MODIOLIFORMES.

2. Cleidophorus striatulus, Waagen, n. sp., Pl. XVIII, fig. 12.

The general form of this shell is about spatulate, very narrow in front and apparently broad and obliquely truncated behind; very inequilateral and tolerably inflated.

The beaks are very much anterior, obtuse, and very little incurved. There is a deep, but very small, roundish lunula in front of the beaks, which is not sharply defined, and not equally well developed in all specimens, causing, according to its development, a more or less strong sinuation in the outline of the shell. The anterior part of the shell is very narrowly rounded and very little prominent. The ventral margin descends from the point of junction with the anterior one, at first forming a slight sinuation and then nearly straight, in an oblique direction to the lower posterior corner of the shell. This latter is narrowly rounded off, and then follows the nearly straight, obliquely truncated, posterior margin, which joins the hinge line in a rather distinct obtuse angle. I regret to say that both specimens of this species have been broken by me in endeavouring to expose them for figuring, and that it has thus become impossible to reproduce in the plates the entire outline of the shell. The hinge line is nearly straight, and the area which accompanies it is extremely narrow, nearly linear.

The hinge is decidedly without cardinal teeth. A very little developed, very

elongated, posterior lateral tooth seems to be present, situated parallel to the posterior hinge margin. It is, however, very difficult, to arrive at a certain conclusion about this point, as the shell is of rather small size and contained in a very hard rock.

Pallial and muscular impressions are not visible; the internal vertical ridge, just in front of the beak, is apparently but little developed.

The shell has tolerably inflated and curved valves, the greatest thickness of them being situated about in the middle of their length. There extends from the beak to the lower posterior corner of the shell in a diagonal direction a broadly rounded, elevated portion of the shell, on both sides of which depressions occur. Below and anteriorly to the elevated part there is a broad low depression, which caused the ventral margin of the shell to be flatly but broadly sinuated; a depressed triangular part of the shell is marked off above and posteriorly.

The surface sculpture is different on different parts of the shell. Anteriorly, as far as the anterior depression extends, it consists only of concentric fine striæ of growth, parallel to the hinge margin. Posteriorly these striæ are crossed by a number of fine radial striæ or costæ, which begin on the beak and extend to the posterior margin. They are not all equal; some of them are stronger, some less strongly developed. Also the different specimens seem to differ in this respect, as the radial sculpture seems in some specimens to be nearly quite obliterated.

The substance of the shell is very thin and fragile.

The dimensions of the larger of the two specimens seem to have been as follows:—

Length of the shell from the anterior end to the lower posterior angle	22 mm.
„ „ „ „ „ to the end of the hinge line	18 „
Breadth of the shell at the anterior part	7 „
„ „ „ „ posterior part	11 „
Thickness of the right valve	3 „
Apical angle	141°

Locality and geological position.—There are two specimens of this species, both right valves, preserved in the Salt-range collection. Both were found by myself at Virgal in a hard grey sandstone forming the top bed of the upper division of the Productus-limestone.

Remarks.—This species is very nearly related to an European permian shell, and I do not doubt that by many men of science both fossils would have been considered as belonging to one and the same species. This shell is *Clidophorus pallasi*, Vern., sp. It must be stated in the first place, that this shell has to be considered as a *Cleidophorus* and not as a *Cardiomorpha*, as King and several American writers have advocated. Though in *Cleidophorus pallasi* itself the posterior lateral tooth may in most cases be obliterated, yet this shell is so extremely nearly related to species which possess a posterior lateral tooth that it is impossible to distinguish it generically from them. Besides this, I know of no case in the genus *Cardiomorpha*, where an internal vertical ridge in front of the beak is found.

Clidophorus pallasi has been already often figured, but all the figures given do not well agree. There seem chiefly two forms comprised under the name; one is longer and narrower in comparison to its breadth; it occurs in Russia and has been figured excellently by Verneuil in the Geology of Russia, and less characteristically, but in many specimens by Golovkinsky. The other is much shorter and broader in comparison to its length; it is very commonly represented in Western Europe, Germany, and England, and has been beautifully figured by Mr. King (under the name of *Cardiomorpha murchisoniana*) and by Geinitz.

The Indian shell resembles chiefly the Russian variety, that is to say the typical *Cleidophorus pallasi*. It seems to be distinct from this species by a somewhat more projecting anterior part of the shell, and by a yet narrower and more elongated general form. The striation on the surface is also more distinct in the Indian fossil than in any of the many varieties of the Russian species.

From the Western European form, which, if specifically distinct, may retain the name of *Cleidophorus murchisonianus*, King, the Indian species is easily distinguishable by its much more elongated general form, longer and straighter hinge line and much less distinct area.

At all events *Cleidophorus striatulus*, W., can be considered as a vicarious species, or as a geographical variety of the permian *Cleidophorus pallasi*.

But there are also some triassic species to which the Indian shell bears a certain resemblance. There has been figured by Giebel under the name of *Mytilus mülleri* a shell found in the Muschelkalk at Lieskau and which, according to the drawing, is very likely a *Cleidophorus*. This shell has been identified by Seebach with *Myoconcha thielaui*, Stromb., but the drawing of the hinge of the latter species given by him shows a rather strong cardinal tooth, and it therefore may be doubted whether Seebach's specimen is a *Cleidophorus*, and whether it is identical with *Mytilus mülleri*, Gieb. Giebel's original drawing shows a shell rather similar on the whole to *Cl. striatulus*, W., but distinct by its even more mytiloid shape, and a radial striation, which is spread nearly over the whole surface of the shell.

Myoconcha gasterochæna, Dunk., also a species from the Muschelkalk, which is even with greater certainty a *Cleidophorus* than those already mentioned, is in its general form more similar to *Cl. striatulus* than *Myt. mülleri*, but on the surface of the shell the radial striation is absent.

Order: ARCACEA.

Family: *TRIGONIIDÆ*.

Genus: SCHIZODUS, King.

This genus is one of those which are most easily recognised among the palæozoic shells, though their distinction from mesozoic ones is not equally easy. But even among the palæozoic fossils there exists some doubt as to the name which

ought to be applied to the shells here under consideration. Several names have been given for similar forms, but have not been equally well characterised.

The oldest name that has been applied to similar shells is that of *Dolabra*, M'Coy. There is no doubt that some of the species described by M'Coy under that name belong in reality to the genus *Schizodus*, but the first three species mentioned by M'Coy are widely different things, and thus it is certainly not proper, as has been done by de Ryckholt, to suppress the name *Schizodus* entirely and place instead that of *Dolabra*, as the latter name must be retained only for those forms described by M'Coy as the first three species.

The next oldest name is *Schizodus*. Since the description of that genus several other shells have been described, which in their general form are more or less similar to King's genus. There is *Anodontopsis*, M'Coy, a genus which in outline is rather nearly allied to *Schizodus*, and which is chiefly distinct by its singular hinge apparatus, which seems to be devoid of distinct cardinal teeth, but possesses apparently of an elongated posterior lateral tooth. I should not like to pronounce any opinion on the systematic position of this genus without having carefully examined a larger number of specimens. The genus has been placed by Stoliczka in the family *Solemyidæ*. Hall on the contrary gives to it a place in the *Mytilidæ*, which latter seems to be the most probable one. Nearly identical in outline with *Schizodus* is *Pseudaxinus*, Salter, chiefly distinct by its very thin shell, and its very little developed hinge apparatus. It must very likely be considered as the predecessor of *Schizodus* in silurian rocks, though also extending in some species into the devonian formation, and even in carboniferous rocks very similar shells occur which are, however, introduced under the name of *Niobe*, Kon. This genus is barely distinct from *Pseudaxinus*, only that the single cardinal tooth is generally more strongly developed. Along with *Pseudaxinus* the genus *Curtonotus*, Salt., occurs in devonian strata, and seems to be even generally preponderating. All palæontologists are not in accordance as to the validity of this genus; and Hall directly considers it as identical with *Schizodus*. If, however, the description given by Salter be correct, which there is no cause to doubt, *Curtonotus* seems to be well distinguishable from *Schizodus*. As Hall takes *Curtonotus* to be identical with *Schizodus*, it becomes very difficult to state at what time the typical forms of *Schizodus* first made their appearance, but it is probable that they are not older than the mountain-limestone. Also in European devonian strata, as in America, species occur which are not dissimilar to *Schizodus*, for instance *Cardinia inflata*, Roem., from the spirifer-sandstone of the Harz, but in these species the median cardinal tooth in the left valve is so very small that they will be better placed in the genus *Curtonotus*.

It is a fact very worthy of notice that among the genera more or less allied to *Schizodus* we find the toothless and thinly shelled ones to be the geologically oldest, whilst through *Curtonotus* to *Schizodus* a very gradual development of the hinge apparatus can be observed; a fact very similar to that which we were able to indicate among the genera more or less allied to *Pleurophorus*. Also here the toothless

Cleidophorus is the older, whilst the strongly toothed *Pleurophorus* makes its appearance only in newer formations, and seems further up in the series of formations more and more to approach *Palæocardites*, though the toothless *Cleidophorus* continues yet along with the teeth-bearing forms.

But also in *Schizodus* the more and more strong development of the hinge apparatus seems not to be arrested. There has been fought out a long controversy as to whether *Schizodus* could be distinguished from the mesozoic genus *Myophoria*, Brown, and it has at last been decided in favour of a distinction. The genus *Neoschizodus*, Giebel, cannot be retained, as has been shown by several authors. *Myophoria* is indeed very nearly allied to *Schizodus*, the cardinal teeth in both valves are perfectly identical, and the only point of difference consists in a more or less strongly developed internal ridge, surrounding the anterior muscular impression at its upper extremity and extending from there a short way up towards the apex of the valves. Also in *Schizodus* a certain tendency exists to develope internal ridges inside the valves, but they are mostly posterior; one case, however, will be demonstrated where anteriorly a kind of thickening of the substance of the shell takes place, approaching very nearly the internal ridge of the *Myophoriæ*.

In *Myophoriæ* for the first time the peculiarity presents itself of the cardinal teeth being partly transversely ribbed at their sides. This peculiarity is yet much more developed in the genus *Trigoniæ*, which is next younger in geological succession, and which shows on the whole an extreme development of the hinge apparatus.

Thus we have been able to follow this series of forms step by step from the toothless silurian *Pseudaxinus* to the recent *Trigoniæ*.

The genus *Schizodus* is rather largely represented in the palæozoic deposits of the Salt-range, and therefore several observations as to the variability of certain characters could be made. We may first note that the hinge teeth are not always developed absolutely in the same manner as represented in King's drawings. In the right valve the posterior cardinal tooth is generally very small and firmly appressed to the hinge margin, superseded by a not long but very distinct fulcrum. Anteriorly the hinge margin is somewhat thickened, forming an indistinct third anterior cardinal tooth. In the left valve the large median cardinal tooth is only rarely distinctly bifid; it is generally only somewhat impressed in the middle. The posterior lateral tooth is extremely small and narrow; the anterior is larger and well developed.

The muscular impressions are sometimes very deep and strong, sometimes rather shallow. In young specimens a sharp ridge sometimes extends from the upper margin of the posterior adductor to near the beak on the inside of the valve, appearing as an incision on the cast. In older specimens, or in other species in young ones also, this ridge is much more indistinct, and is entirely absent in others.

The pallial impression is rather strongly marked in most species. It is not

simply truncate posteriorly, as it has been drawn by King, but in most cases a very slight sinuation is observable in the posterior part of it. It joins the posterior muscular impression about in its middle.

The genus constitutes a rather compact set of forms, and neither in sculpture nor in outline do great variations take place, and so it is impossible to distinguish any large sections within the genus; even the specific distinctions become in most cases very difficult. Only with the appearence of the genus *Myophoria*, the geologically oldest species of which seem to occur in the Salt-range, does a greater variability of the forms arise, reaching its maximum in the genus *Trigonia*.

There occur not less than four species of this genus in the palæozoic deposits of the Salt-range, but only one of these can be identified with tolerable certainty with an European shell; this is *Schizodus rotundatus*, Brown, which occurs in numerous specimens in the upper division of the Productus-limestone. Two others, beyond doubt, must be considered as vicarious forms of shells occurring in the permian formation of Europe. One of them I shall call *Schiz. pinguis*, W. It is very nearly allied to *Schiz. obscurus*, Sow., and by many men of science both forms will be considered as identical. There are, however, as will be shown in the description of the species, some differences which make it more probable that we have to deal here with vicarious forms rather than with identical species. The same is the case with another species which I shall describe under the name of *Schiz. dubiiformis*, W. This fossil agrees very nearly with *Schiz. dubius*, Schloth., (*Schiz. schlotheimi*, Gein), but is not so far identical that it could be considered as the same species; this is also with great probability a vicarious form.

The last species, for which I shall introduce the name of *Schiz. compressus*, W., seems to be more or less allied to a species that has been described under the name of *Sch. planus*, Gol., from the permian beds of Russia.

It is a fact worthy of notice that all the species of *Schizodus* occurring in the Salt-range show a by far greater affinity to European than to American species, a fact which is the reverse of what I have been able to state for most of the Gasteropoda.

1. Schizodus rotundatus, Brown, sp., Pl. XIX, figs. 11, 12.

1841. *Axinus rotundatus*, Brown: Transact. Manch. Geol. Soc., Vol. I, p. 31, pl. VI, fig. 29.
1850. *Schizodus rotundatus* (Brown) King: Monogr. Perm. Foss., p. 190, pl. XV, fig. 30.
1861. *Schizodus Schlotheimi*, Geinitz: Dyas, p. 64 (Syn. *rotundatus*).

This species has been already sufficiently well described by King, and I can only give here a description of the Indian specimens in order to facilitate a comparison with the typical form.

The general outline of the shell is more or less shortly oval, broadly rounded in front, and obliquely truncate behind. The beaks are about median in their position, not much prominent, pointed but very little incurved, just projecting a little above the angular hinge line. The anterior margin of the shell is rather

strongly projecting and broadly rounded as stated above, and so also is the ventral margin, which is, however, in some specimens slightly sinuated just in front of the lower posterior corner of the shell. This corner is tolerably angular and prominent, and from it ascends the nearly straight posterior margin of the shell in an oblique direction, joining the hinge line at an obtuse angle.

There is no lunula in front of the beaks, and no distinct area behind them. A short external ligament is situated just behind the beaks, and is supported by distinct fulcra. The hinge apparatus itself has not been observed by me in any of the Indian specimens.

The surface of the shell is not much vaulted. From the apex to the lower posterior corner there extends a distinctly marked, slightly curved angular ridge, mostly accompanied on its anterior side by a very shallow depression. Posteriorly to the ridge a flattened triangular space is marked off. The surface sculpture consists simply in irregular striæ of growth, more strongly marked at intervals.

The substance of the shell is rather solid, similar to that usual in *Schiz. rotundatus*, Brown.

The dimensions of two specimens (one right and one left valve) from Katwâhi are as follows :—

	I.	II.
Entire length of the shell	27 mm.	15 mm.
„ breadth „	22 „	13 „
Thickness of one valve	7 „	4 „
Apical angle	120°	123°

No large specimens of this species have been observed by me in the Salt-range.

Locality and geological position.—This species is not rare at certain localities in the Salt-range, but seems to be entirely restricted to the upper division of the Productus-limestone. Most of the specimens were collected by myself near Katwâhi, on the road to Shahpur, in a yellowish-grey friable sandstone forming part of the middle region of the upper division of the Productus-limestone. There are eight specimens from this locality (five right and three left valves), which all have their shell preserved. At other localities the species seems to be less numerous. Two small specimens of it were collected by me at Chidru in the top bed of the upper division of the Productus-limestone, and another (duplicate) was found by M. Wynne at Khund Ghât together with a great lot of other fossil, characteristic of the upper division of the Productus-limestone.

Remarks.—Though the shells which I consider to belong to *Sch. rotundatus*, Brown, show a very great resemblance to the typical form as figured by King, yet some slight differences might be pointed out, which are, however, barely of sufficient importance to warrant a specific distinction of the Indian fossils. Firstly, it may be noticed that the Indian specimens attain a much more considerable size than is stated for *Schiz. rotundatus*. The figure by King represents the species already twice magnified, and thus the original was only as large as the smallest specimens I have for description from India. But in specimens of a similar size

the form of the Indian shell is perfectly identical with King's figure. Large specimens become somewhat more elongated in comparison to their breadth; but one character is always very conspicuous; this is the very considerable development of the anterior part of the shell, in consequence of which the apex becomes nearly median in its position. In young specimens this position is entirely median, but in old ones the posterior part of the shell is a little more produced, and thus the position of the apex is shifted slightly towards the anterior side.

Another character in which the Indian fossil agrees with *Schiz. rotundatus* is the solidity of its valves, which occurs also, according to King's description, in the English fossil. This latter character, the solidity of the valves, has evidently been overlooked by Geinitz, when he identified *Schiz. rotundatus* with his *Schiz. schlotheimi*. Thus, in comparing the Indian shells with Brown's species, there can absolutely be detected no other characters of distinction except the large size of the Indian specimens. But this alone is certainly not sufficient for the distinction of a proper species.

For a long time I have been in doubt whether I should not better identify the shells here under consideration with *Schizodus truncatus*, King, with which they would better agree in size; but as far as I have been able to examine specimens undoubtedly belonging to King's species, this seemed always to possess a less strongly projecting anterior part of the shell and more inflated valves. There has been figured by Geinitz (Dyas, Pl. XIII, fig. 4) a specimen as *Sch. truncatus*, which approaches very near the form of the Indian shell, but yet this is more inequilateral than are equally sized specimens from India.

A question very difficult to solve is, whether *Schiz. rossicus*, Vern., ought to be considered as identical with *Schiz. rotundatus*. It is very much to be regretted that the figures in the Geology of Russia are drawn from so very small specimens, and have not been enlarged, so that it becomes more or less difficult to judge of the characters of this species. As far as is known to me the species has never been figured again from better Russian materials, but it has been considered by von Möller as identical with *Schiz. truncatus*. In describing the species, Verneuil compares it to *Sch. schlotheimi*, Gein., but states that it is distinct from that species by a shorter posterior part of the shell. From all this it is barely possible to come to any definite conclusion, and as long as no better figures exist, *Sch. rossicus* will always remain a doubtful species. The shells figured by Geinitz under the name of *Sch. rossicus* from Nebrasca may be identical with Verneuil's species, but they are certainly not identical with *Sch. rotundatus* and with our Indian fossils. The identification of the specimens figured by Geinitz with *Sch. entus*, M. and W., as asserted by Meek and Hayden, is however decidedly mistaken.

Of other species, *Schizodus wheeleri*, Swall., is most nearly allied to the shells here under consideration. But from this species our Indian fossils are well distinguishable by the shorter posterior part of their shell and the more median position of the apex.

Among the lower carboniferous species there are several more or less similar to the present one, but I think that it cannot be identified with any of them with greater right than with *Schiz. rotundatus*.

2. Schizodus pinguis, Waagen, n. sp., Pl. XIX, figs. 7—10.

The general outline of this shell is about axiniform or elongately oval, the valves are very strongly inflated, the surface of the shell nearly quite smooth.

The beaks are inflated, little prominent, pointed and distinctly bent over. The anterior margin is very broadly rounded; the ventral margin also forms a very flat arch. Where this latter joins the posterior margin a very obtusely prominent and rounded-off corner is formed.

The posterior shell margin is short and straight, ascending in an oblique direction. It forms an obtuse angle with the hinge line, which ascends straight and very obliquely to near the beak.

There is no lunula in front of the beaks, nor any area posteriorly to them. Just behind the beak there is an external ligament, not very long, supported by strong and distinct fulcra.

The hinge apparatus could be observed in both valves. In the right valve there is a very strong median cardinal tooth, and a rather long but very compressed posterior cardinal, which is for its entire length attached to the hinge margin. Between these two cardinal teeth a very large triangular pit is placed. Anteriorly to the median cardinal tooth there is a smaller pit, rather narrow, limited on its anterior side by the hinge margin, which is, however, in this place very considerably thickened, so as to form nearly a third cardinal tooth. Lateral teeth seem not to exist. In the left valve there is a large indistinctly bifid tooth, a little posterior in its position and fitting into the largest pit of the right valve. Anteriorly to it there is a large triangular groove for the reception of the large tooth in the right valve; it is limited on its anterior side by a narrow, but very distinct second cardinal tooth, entirely detached from the hinge margin, but not much divergent with it, and separated from it by a deep, long and narrow groove.

Posteriorly to the large cardinal tooth lies a deep and narrow groove for the reception of the posterior cardinal tooth in the right valve. An indistinct third posterior cardinal tooth follows, which is attached for its entire length to the hinge margin, and but little projecting. Above it is placed the fulcrum for the support of the ligament.

The surface of the shell is very strongly arched in every way; only from the apex to the lower posterior corner of the shell there extends a curved, very obtuse, barely perceptible ridge, which marks off a triangular flattened posterior part of the shell. Not a trace can be observed of any kind of surface sculpture, even with the lens; the shell appears to be nearly quite smooth, only with difficulty can some very fine striæ of growth be observed.

The substance of the shell is thick and solid, and so, the muscular and pallial impressions are strong and deep. These latter, however, are better observed on internal casts, which can sometimes be prepared: they are very strongly arched and show the pallial and muscular impressions in an excellent manner. The anterior muscular impression is roundish, not very large and somewhat sunk in the cast, and thus supported by a thickening of the substance of the shell in specimens showing the inside of the valve. This thickening extends from the muscular impression upwards, towards the beaks, forming a kind of thick broad ridge, which extends laterally to the hinge margin, causing also this part of the shell to be thickened and swollen. Thus a condition of the shell prevails which very nearly approaches that of *Myophoria*. From the anterior side of the anterior muscular impression the pallial line descends in a flat arch, about parallel in its direction to the shell margin, forming further-on a nearly straight, only very little curved, line. In approaching the posterior part of the shell it suddenly bends round, forming an obtuse angle, and ascends in an oblique direction to meet the posterior muscular impression at its posterior margin; just before reaching it the pallial line shows a very slight and shallow sinuation. The posterior muscular impression is of an oval shape and very prominent in the cast, surrounded anteriorly by a sharp edge. Separated from this muscular impression by a broadly rounded excavation, and more approached to the apex, is a small slight triangular impression, caused by the insertion of the pedal muscle.

The dimensions of the largest specimen from Chidru are as follows:—

Entire length of the shell	33 mm.
„ breadth „	27 „
Thickness of the right valve	10 „
Apical angle	115°

Locality and geological position.—This species is very common in the Salt-range, and entirely restricted to the upper division of the Productus-limestone, as far as has been observed up to the present. It was numerously observed by me in the mountains east of Katwáhi, where it fills a whole bed with hundreds of specimens; this bed is situated not more than six feet below the lowest strata of the ceratite formation. The specimens are, however, for the most part badly preserved. Other specimens of this species were collected by myself at Chidru in the middle region of the upper division of the Productus-limestone (two specimens, one right and one left valve), as well as in the top beds (also one right and one left valve), and Trans-Indus at Káfirkot (two left valves).

Remarks.—This species is a very characteristic fossil of the upper division of the Productus-limestone, and seems to represent in the Salt-range the *Schiz. obscurus*, Sow., of the permian formation of Europe. It is allied to Sowerby's species by the great solidity of its shell, and the general outline, but can be distinguished by its less prominent and less narrow posterior side, by the greater

inflation of its valves and by its smooth surface. The constantly smaller size may also constitute a point of distinction.

Very similar in shape is also *Schizodus* (*Donax*) *sulcatus*, Sow., from Coalbrook Dale; but also here the greater shortness, inflation, and solidity of the Indian shell, which is also less distinctly carinated, make a distinction not difficult.

Though this species by the peculiar thickening of the substance of its shell above the anterior muscular impression very nearly approaches the genus *Myophoria*, and must be considered as a truly transitional form, yet I have placed it in the genus *Schizodus* on account of its great similarity to *Sch. obscurus*, Sow.

3. Schizodus dubiiformis, Waagen, n. sp. Pl. XIX, figs. 15—16.

The general form of this species is transversely oval, with prominent beaks, everywhere rounded margins, and not much inflated valves.

The beaks are strongly prominent, thin, pointed, and rather strongly incurved. They are nearly median in position, the whole outline of the valves being but very little inequilateral; thus the beaks are only slightly anterior. There is a slight excavation in front of them, causing the formation of a very small indistinct form of lunula.

The anterior margin of the shell is very broadly rounded and strongly prominent. A much flatter curve is formed by the ventral margin, which latter joins the posterior margin in forming a very obtuse, barely perceptible angle. The posterior margin is not quite straight; it shows a very flat arch, and unites with the sloping hinge line under a very obtuse angle. There is no trace of an area behind the beaks.

The surface of the shell is nearly quite smooth. There extends a very indistinct angular curved ridge from the beak to the lower posterior corner of the shell; it is, however, in some specimens barely perceptible. By it a triangular flattened posterior part of the shell is marked off. Otherwise the whole surface is covered by very fine, irregular, barely visible concentric striæ of growth, of which only some few are more strongly marked, though these also are very little conspicuous.

Immediately behind and partly below the beaks there is an extremely small external ligament, supported by equally small fulcra. The whole hinge apparatus is very reduced in size, but showing the characteristic features of *Schizodus*. Only the hinge of the right valve is known to me. There are two very small but distinct cardinal teeth, of which the posterior one is for its entire length united with the hinge margin. The anterior tooth is very little larger, separated from the posterior one by a large triangular pit; it descends in an oblique direction towards the anterior part of the shell. In front of this anterior cardinal tooth there is a smaller oblique triangular pit, limited on its upper side by the hinge margin, which is not thickened.

On the inside of the shell the muscular impressions are situated very high up near the hinge line. They are rather strongly marked in some specimens; in others they are barely perceptible. The impression of the anterior adductor is tolerably large, oval in shape, and situated very near the margin of the shell; it is joined on its anterior side by the pallial impression, which descends from there and proceeds about parallel to the ventral margin, forming a flat curve along it, to the posterior part, where it suddenly turns up, forming a blunt obtuse corner and showing a very shallow sinuation above, to meet the impression of the posterior adductor. This latter is very small, roundish, and mostly rather strongly marked.

In well preserved casts, besides the impressions just described, there descends from within the beak to the posterior part of the shell, not quite reaching the posterior muscular impression, an impression of a shelly ridge, which seems to have served to strengthen the very thin and brittle shell.

The substance of the shell is extremely thin and quite transparent, showing in this respect a great similarity to the shell of *Schiz. dubius*, Schl. (*Schiz. schlotheimi*, Gein.).

The dimensions of a full-grown specimen are as follows:—

Entire length of the shell	29 mm.
„ breadth „	24 „
Thickness of the right valve	6 „
Apical angle	113°

Locality and geological position.—This species was found by myself at one locality only, but in tolerably large numbers, at Chidru, where it occurs in a yellowish-grey hard sandstone, forming the top bed of the upper division of the Productus-limestone. On account of the great thinness of the shell, most of the specimens were already in a broken state in the rock. I was able to bring away only five tolerably well preserved specimens (three left and two right valves).

Remarks.—This species is rather nearly related to *Schiz. dubius*, Schloth., and very likely must be considered as the representative of that species in India. Like *Sch. dubius*, also *Sch. dubiiformis* possesses a very thin and fragile shell, and has the angular ridge, extending from the beak to the lower posterior corner of the shell, very little developed. It is distinct by its beak, which has in all stages of growth about the same relative size, whilst it gets thick and inflated in older specimens of *Sch. dubius*; and by the less elongated posterior part of the shell.

Thus the three principal types of *Schizodus* occurring in the permian strata of Europe are represented in the palæozoic deposits of the Salt-range: the type of *Sch. truncatus*, King, by *Sch. rotundatus*, Brown; the type of *Sch. obscurus*, Sow., by *Sch. pinguis*, W.; and the type of *Sch. dubius*, Schl., by *Sch. dubiiformis*, W. A fourth type which occurs in the permian beds of Russia is represented by the next described species.

4. SCHIZODUS COMPRESSUS, Waagen, n. sp. Pl. XIX, fig. 6.

This is a rather large species, one of the largest as yet known to exist within the genus.

The general form of the shell is roundish-oval, the valves very compressed, without prominent sculpture.

The beaks are not very prominent, pointed, but barely incurved, somewhat anterior in their position. There is no indication of a lunula in front of them; but the valves are perfectly continuous, the beaks being appressed to each other.

The anterior margin of the shell is not perfectly preserved, but seems to have been very broadly rounded, perfectly continuous with the ventral margin, which shows also a broad prominent curve. It unites with the posterior margin in forming a broadly rounded obtuse angle. The posterior margin is very short, flatly arched, oblique, joining the sloping hinge line under a very obtuse angle.

The surface of the shell is very flat, without prominent sculpture. There extends from the apex to the lower posterior corner a curved, obtusely angular ridge which marks off a triangular flattened posterior space of the shell. The surface is covered by irregular very fine concentric striæ of growth.

The substance of the shell is very solid.

Immediately behind the beaks there is a somewhat long external ligament, supported by very strong fulcra. The hinge apparatus is tolerably well visible, but only that of the left valve is known to me. It has three cardinal teeth, of which, however, only one is very distinct, not bifid, triangular in shape, somewhat posterior and oblique in its position. In front of it there is an extremely large triangular groove, and then follows a long but very narrow anterior cardinal tooth, which is for the greater part of its extent united with the hinge margin. Behind the principal cardinal tooth there is a very narrow slit-like triangular groove, and then follows a very indistinct posterior cardinal tooth, which is for its entire length joined to the hinge margin, and is limited above by the fulcrum for the support of the ligament.

Muscular and pallial impressions cannot be observed.

The only specimen of this species exhibits the following dimensions:—

Entire length of the shell, about	50 mm.
„ breadth „ „ „	41 „
Distance of the lower posterior corner from the apex	37 „
Length of the posterior margin	17 „
Thickness of the left valve	8 „
Apical angle	128°

Locality and geological position.—The only specimen of this species preserved in the Salt-range collection was found by myself at Kufri in a yellow oolitic limestone forming part of the upper division of the Productus-limestone (division No. 14 of my note-book).

Remarks.—This species, by its compressed form and large size, is rather nearly related to a shell described by Golovkinsky from the permian beds of the country round Kasan, under the name of *Schiz. planus*, Gol.; the Indian species is, however, easily distinguishable from this fossil by its greater shortness and the more median position of its beaks.

Golovkinsky, in describing the *Sch. planus*, points out certain peculiarities which, according to his views, occur in the hinge apparatus of his species, and which he states to consist in the hinge of the left valve bearing two, and that of the right valve three, cardinal teeth, a statement which seems not to be borne out by his figures.[1]

Of carboniferous species none is known to me which could be particularly compared to the present species.

Genus MYOPHORIA, *Bronn.*

If one wished to be rigorous in the retention of genera, and to accept only those which in every case can be readily distinguished, the genus *Myophoria* would certainly not be among those which could be retained, if one had to describe a rich fauna of bivalves from upper palæozoic strata. The forms of the triassic species of *Myophoria* are as characteristic and well distinguishable, as are uncertain the characters of some shells which I have presently to describe.

In upper palæozoic strata the genus *Myophoria* seems to be just in process of being coined, and thus a number of shells occurs in which the characteristic feature of the genus (a ridge extending internally from the anterior muscular impression up to the apex) is developed in a way that it seems quite optional whether such a fossil should better be retained in the genus *Schizodus*, or should be removed to the genus *Myophoria*.

Already in describing the *Schizodus pinguis* I was in a position to point out how the generic determination of this fossil was not above every objection, as a peculiar thickening of the shell at the place where the anterior adductor was inserted and extending up to near the apex appeared to be very similar to the internal ridge which characterises the typical species of *Myophoria*. I preferred in that case to ignore this peculiarity, as it was not exactly like that occurring in *Myophoria*, and because the shell bearing this character was in every other respect very nearly allied to *Schiz. obscurus*, Sow., so that it did not seem advisable to place the two shells in two different genera.

The case stands otherwise with several other species occurring in the Salt-range. Only in one of them, to which I shall give the name of *Myoph. præcox*, W., is the characteristic internal anterior ridge of *Myophoria* typically developed, and its belonging to the genus cannot be questioned; two other species, however, have this character

[1] Materials for the Geology of Russia, Vol. I, 1869: On the Permian formation of the Kama-Volga Basin, page 368, pl. III, figs. 21—23. (Original in Russian.)

not more strongly developed than is exhibited by *Schiz. pinguis*, W. Nevertheless these two also may more conveniently be considered as belonging to the genus *Myophoria* than to *Schizodus*, as they have their nearest relations not among the species of *Schizodus*, but among the *Myophoria*. One of them seems to be most nearly allied to *Myoph. cardissoides*, Alb., and therefore will bear the name of *Myoph. cardissa*, W.; the other is very similar to *Myoph. elegans*, Dunk. (*Myoph. curvirostris*, Ant.), and thus will best be called *Myoph. sub-elegans*, W.

It might be considered as a somewhat strange way of proceeding not to assign species simply according to the similarities they exhibit to one or the other genus, but to take also other considerations into account. One might say: either the genus *Myophoria* stands, and all the shells which do not exactly present the characters of the genus must be considered as belonging to other genera; or, the genus *Myophoria* cannot be kept up as distinct, and then the name of *Myophoria* would have to supersede that of *Schizodus*, and all the species, which are now counted as belonging to the two genera, would have to bear the first of the two names. If the first case be adopted, the species here under consideration, *viz.*, *Schiz. pinguis*, W., *Myoph. cardissa*, W., and *Myoph. sub-elegans*, W., would very likely have to be considered as forming a separate genus, as they do not agree entirely either with *Schizodus* or with *Myophoria;* but then the new genus would only be based upon the degree (more or less) of one character, and comprise a very small set of forms, on the one hand in perfect transition with *Schizodus*, on the other with *Myophoria*.

If, however, we take the second case into consideration we find that the species of *Schizodus* as well as those of *Myophoria* known up to the present have been very well distinguishable generically, and that there are only the few species from the Salt-range which establish a transition of the characters of the two genera. Ought we then, only on account of these Salt-range species, entirely to suppress the one name, though in most cases the two genera are perfectly distinguishable? There is evidently some cause, of place or of time, by reason of which intermediate forms between the two genera appear in the palæozoic deposits of the Salt-range; but it does not seem to me practicable that these local occurrences should be taken to disturb long-established facts so as entirely to overthrow the conclusions which have been drawn from them.

One thing is established upon evidence from these Salt-range fossils, that it is chiefly a difference in time and locality which makes a distinction between the two genera possible, and that the limits between them disappear as soon as these differences in time and locality vanish; in other words, that during the time of the deposition of the palæozoic strata in the Salt-range, the genus *Myophoria* began to be developed out of different species of *Schizodus*, or, to use a term applied above, began to be coined. In the lapse of time between the deposition of the Salt-range strata and the European trias by changing their place of abode, the shells got the

character of the internal ridge more strongly and more constantly developed, and formed then a well distinguishable genus; but this genus ought to be retained also for the Salt-range shells, here under consideration, as their affinity lies entirely with the more recent *Myophoriæ*.

1. Myophoria præcox, Waagen, n. sp. Plate XIX, figs. 17—19.

This is a rather small species, bearing a very characteristic sculpture. The general outline is transversely ovate, inequilateral, slightly truncated behind, broadly rounded in front, with valves not much inflated.

The beaks are rather prominent, distinctly pointed, well incurved. There is a very small rounded indistinct kind of lunula in front of them. The anterior margin of the shell is broadly rounded, not much projecting. It joins without demarcation the ventral margin, which is flatly arched. Where the latter meets the posterior margin a rounded corner is formed. The posterior margin ascends obliquely, and is very slightly curved; it joins the sloping hinge line in forming a very obtuse rounded angle. There is no trace of an area behind the beaks.

The surface of the shell is tolerably strongly arched. From the apex to the lower posterior corner there extends an angular ridge which marks off a rather broad posterior triangular space. Upon this posterior part of the shell a second radiating flat ridge can be observed, but it is very indistinct. The whole surface of the shell is covered by a neat concentric striation, which is very characteristic, so much so that every small fragment of the shell can readily be recognised by it as belonging to the present species. This striation is very fine and closely arranged near the apex, whilst the striæ are more distant from each other near the ventral margin. They are not caused by lines of growth, but are an independent sculpturing characteristic of the shell. The single striæ are rounded on the top near the apex, and imbricating near the ventral margin. The striation is much finer and less distinct on the posterior triangular part of the shell than on the remaining surface.

The hinge apparatus is only known to me from an excellently preserved internal cast of the right valve which I have been able to prepare. It consists in this valve of one very large and prominent cardinal tooth, not quite vertical, but somewhat inclined towards the anterior side of the shell. Posteriorly there seems to be a second cardinal tooth, very obliquely situated, but very narrow and rather indistinct. The fulcrum for the support of the ligament, which must have been above this tooth, cannot be observed. Immediately in front of the beak there is the impression of a sharp but not very long ridge, extending from within the apex towards the anterior muscular impresssion. The muscular impressions seem both to have been situated very high up towards the hinge margin, but they are so very indistinct that no exact observation is possible. Also the pallial impression cannot be seen.

The substance of the shell is tolerably solid.

The measurements of two specimens, one from Virgal (duplicate) and one from Chidru (left valve) are as follows:—

	I.	II.
Entire length of the shell	9·5 mm.	17 mm.
„ breadth „	9 „	15 „
Thickness of both valves	5 „	...
„ of the left valve	...	4 „
Apical angle	120°	125°

The specimen No. II is the largest that has been found up to the present.

Locality and geological position.—This species seems to be restricted to the top bed of the upper division of the Productus-limestone. It has been found in this bed by myself at Chidru (two left and one right valve) and at Virgal (one duplicate).

Remarks.—This is, as far as is known to me, the geologically oldest species of an undoubted *Myophoria* that has been described up to the present. The condition of the cast, which I was fortunate enough to be able to prepare, shows beyond any doubt that we have to deal here with a true *Myophoria* which is already rather nearly related to some triassic species.

Of triassic forms, *Myoph. orbicularis*, Bronn, seems to be most nearly related, and even the long posterior impression (? a muscular impression), which has been drawn on the cast of the triassic fossil by Seebach, is to be found again less distinctly in our specimen, only the posterior ridge which he describes is absent. Specimens of this triassic species with the shell preserved have been figured by Giebel under the name of *Lucina plebeja*. In general form they are not at all dissimilar to our *Myoph. præcox*, but they have their apex a little more median in its position, and their surface is described by Giebel as smooth and shining, the characteristic sculpture of *Myophoria præcox* being thus decidedly absent in *Myoph. orbicularis*.

Also *Myoph. ovata*, Bronn, might be compared to the present species, but it has a narrower and more prominent posterior part of the shell.

Of permian and lower carboniferous species there is none with which the fossil here under consideration could be particularly compared.

2. Myophoria cardissa, Waagen, n. sp. Plate XXIV, figs. 10—11.

This is a middle-sized species of triangular shape, but little inequilateral, about as long as it is high.

The beaks are nearly median, very little anterior in their position, not much prominent, pointed, and little incurved. There is barely a trace of a lunula in front of them. The anterior margin is broadly rounded and little prominent, and unites with the more flatly curved ventral margin without any interruption or

demarcation. The lower posterior corner of the shell, where the ventral and posterior margins meet, is well rounded. The posterior margin ascends obliquely in a nearly straight line, and unites with the rather short sloping hinge line in forming a very obtuse angle. A kind of a very narrow and short area extends along the hinge line, forming an elongated groove between the two valves in which the short ligament is lodged.

The surface of the shell is not very strongly arched, and in consequence of this the valves are not much inflated. From the apex to the lower posterior corner of the shell there extends a distinct angular ridge, not very sharp, marking off a very narrow posterior triangular space. Otherwise the surface of the shell is only covered by very fine striæ of growth, which are very rarely, and only in some specimens, interrupted by stronger concentric folds, marking stages of growth.

The hinge apparatus cannot be observed in any of the specimens.

An artificial internal cast which I tried to prepare seems to show a thickening of the shell above the anterior muscular impression. Though it is not easy to arrive at a certainty on this point, yet the existence of such a thickening is highly probable from the appearance of this cast. The posterior muscular and the pallial impressions could not be observed.

The substance of the shell is tolerably solid.

The dimensions of the largest specimen of this species which has been found up to the present are as follows:—

Entire length of the shell	25 mm.
„ breadth „	23 „
Thickness of the left valve	5 „
Apical angle	110°

Locality and geological position.—There is only one locality where specimens of this species have been found; this is near Katwáhi on the road to Shahpur, where I collected four specimens (three left valves and one right one) in a light greyish-yellow, very friable, sandstone belonging to the middle region of the upper division of the Productus-limestone.

Remarks.—This species can only with difficulty be compared to carboniferous or permian fossils. In the mountain-limestone there is only *Dolabra securiformis*, M'Coy, which can at all be compared, but it is much less triangular, and thus only slightly similar to our *Myoph. cardissa*. The same is the case with *Schizodus truncatus*, King, and the other permian species of *Schizodus*. Only among the triassic species of *Myophoria* more similar shells can be detected.

There are chiefly *Myoph. cardissoides*, Alb., and *lævigata*, Alb., very similar to the species here under consideration. Both seem, however, to be distinct by the height or breadth of the shell being more considerable in comparison to the length, by a more flatly arched ventral margin and by the angular ridge, extending from the apex to the lower posterior corner of the shell, being more acute. On the whole it appears, however, highly probable that *Myoph. cardissa* will have to be considered

as the ancestor of the two species from the Muschelkalk, a circumstance which would be much more apparent, if any species allied to *Myoph. cardissoides* were to be detected in the lower Bunt Sandstein formation.

3. Myophoria sub-elegans, Waagen, n. sp. Pl. XIX, figs. 13—14.

This species, of rather moderate size, has a more or less roundish general outline, with a broadly rounded anterior, and a truncated posterior side, sub-central beaks, and rather much inflated valves.

The beaks are very small, very little prominent, strongly pointed, and distinctly incurved towards the posterior side of the shell. There is barely a trace of a lunula in front of them, but the whole anterior side of the shell is slightly impressed, forming a kind of anterior area. The anterior shell margin is very broadly rounded and strongly prominent, forming (chiefly in its lower part, together with the anterior part of the much vaulted ventral margin) a very prominent semi-circular outline. Posteriorly the ventral margin is very distinctly sinuated, and the lower posterior corner of the shell is pointed and strongly projecting. The posterior margin of the shell is but very little oblique, nearly straight, very little sinuated in the middle; it joins the sloping hinge line under a distinct obtuse angle.

The surface of the shell is rather strongly vaulted, and thus are the valves rather much inflated. Anteriorly an indistinct angular elevation extends a short way down from the apex, not quite reaching the margin, and marking off a kind of anterior area. Much more distinct is a strong prominent ridge which takes its origin posteriorly at the apex and runs from there in a somewhat curved line to the lower posterior corner of the shell. For its whole extent it is limited on its anterior side by a very distinct excavation. Posteriorly a more or less flat triangular space of the shell is marked off by this ridge. On the middle of this triangular space a second radiating rib may be discerned, but much less strongly developed.

The surface sculpture of the shell consists, in very numerous and very sharp concentric costæ, nearly parallel to the shell margin over the whole extent of the shell. The costæ themselves are angular and separated from each other by flat spaces.

The substance of the shell is tolerably solid.

The hinge apparatus could not be well observed in any of the specimens. One right valve from Virgal seems to possess a rather large anterior cardinal tooth, in front of and behind which large grooves are situated. Another posterior cardinal tooth is smaller, and joined for the greater part to the hinge margin; still, however, it is comparatively rather large. The external ligament is rather long and supported by a very strong fulcrum. On the whole the hinge seems to be absolutely identical with the hinge of the right valve of *Neoschizodus curvirostris* (*Myoph. elegans*) as figured by Giebel.

I did not succeed in preparing an artificial internal cast; from what I could observe, however, it seems probable that an internal thickening of the shell occurs above the insertion of the anterior adductor.

The general shape of the species is not absolutely identical in all stages of growth, young specimens are more broadly oval than old ones.

The dimensions of the largest specimen from Chidru are as follows:—

Entire length of the shell	12	mm.
„ breadth „	12	„
Thickness of the right valve	3·5	„
Apical angle	112°	

The species seems not to attain any larger size.

Locality and geological position.—This species is not rare in the top bed of the upper division of the Productus-limestone, but seems to be restricted to that horizon. It has been collected by myself in this bed at Chidru (one right valve) and at Virgal (one duplicate, three left and two right valves).

Remarks.—As in the preceding species, also in this one its position in the genus *Myophoria* might be questioned; but on the one hand the thickening of the shell which seems to occur above the anterior adductor, on the other hand the near relation in which this shell stands to typical triassic species of *Myophoria*, seem to warrant its position in the genus.

The nearest relation to the present species is beyond doubt *Myoph. elegans*, Dunk. (*Myoph. curvirostris.* Gdf.). If we compare shell-bearing specimens of both species, the differences may be stated to consist in the following points:—*Myoph. elegans*, D., is more trigonal in its general outline than the Indian shell; the furrow in front of the posterior transverse ridge is deeper and more strongly expressed, and the concentric striation is less fine and less numerous.

These differences are certainly sufficient to distinguish the species, but otherwise a very near relationship of the two shells cannot be denied.

Thus we have already three very characteristic types of German Muschelkalk fossils represented in the palæozoic deposits of the Salt-range:—

Myophoria orbicularis, Bronn, is represented by *Myoph. præcox*, W.;

Myophoria cardissoides, Alb., is represented by *Myoph. cardissa*, W.; and

Myophoria elegans, Dunk., is represented by *Myoph. sub-elegans*, W.

This is again a very striking proof of the mixed character exhibited by the fauna of the palæozoic deposits of the Salt-range.

Family: *NUCULANIDÆ.*

Sub-Family: *NUCULANINÆ.*

Genus: NUCULANA, Link.

It is only by the external form of the shell that I assign a species from the Salt-range to the genus *Nuculana*, the internal characters, sinuosity of the pallial impression and size of the cartilage pit, cannot be seen in the specimens at my disposal.

The genus *Nuculana* seems to date very far back in the geological series; though it is difficult to arrive at any certain conclusion about the matter, yet it is highly probable that already in devonian strata true species of *Nuculana* existed. From these upwards in every formation up to the present time species of the genus occur, though they are rarely very numerous. It is barely possible to indicate any period in which the genus may have had its chief development, as the species are very equally distributed throughout the whole series of formations.

The name *Nuculana* must stand in preference to *Leda*, Schum., for two reasons: first, because *Nuculana* has long priority; and second, because the name *Leda* had already been pre-occupied for a genus of Arachnids.

1. NUCULANA SUBACUTA, Waagen, n. sp. Pl. XX, figs. 1—2.

This is a very small species of which up to the present only two specimens have been detected.

The general form is elongately oval, inequilateral, pointed behind, and tolerably broadly rounded in front, with very prominent beaks, and not very inflated valves.

The beaks are excentric in their position, situated more towards the anterior part of the shell, thin, pointed, and very strongly incurved. There is a small, very deep, but not sharply defined, lunula, which causes a distinct sinuation of the outline of the shell just in front of the beaks. The anterior margin of the shell is strongly prominent, but not very broadly rounded. It unites without demarcation with the ventral margin, which is broadly and flatly arched. There is no distinct posterior margin, the ventral margin uniting directly with the hinge line in forming a rounded acute angle. The hinge line is posteriorly slightly excavated, and shows a distinct sinuation just behind the beak. Along the posterior part of the hinge line an indistinct sort of area is present, which is impressed and limited on both sides by very indistinct rounded ridges. The impressed or excavated condition of this area is the cause that the hinge line proper cannot be seen in a side-view of the shell.

The surface of the shell is tolerably strongly arched, the greatest thickness of the valves being situated at about the middle of the height of the shell below the

beak. The whole surface of the shell is covered by a very regular and very fine concentric striation. There are about thirty raised striæ with as many equally broad furrows between them. They are all parallel to the ventral and anterior borders of the shell.

The substance of the shell is tolerably solid.

The hinge cannot be well observed on account of the very diminutive size of the shell, but it seems that the hinge teeth are not so very numerous, and comparatively not so very small. The internal cartilage pit cannot be seen.

As there were only two specimens of this species it has not been possible to prepare an artificial cast, nothing could therefore be observed of the pallial and muscular impressions.

The measurements of one of the specimens are as follows:—

Entire length of the shell, about	8	mm.
„ breadth „	6	„
Thickness of the left valve	2·5	„
Apical angle	115°	

Locality and geological position.—The only two specimens (a right and a left valve) of this species in the Salt-range collection were found by myself at Chidru, in a hard yellow sandstone forming the top bed of the upper division of the Productus-limestone.

Remarks.—The species which seems to be most nearly related to the Indian shell is *Nucula acuta*, Sow., from Coalbrook Dale. The two species are so very similar to each other that I thought it barely possible to distinguish them, but on a closer examination certain differences can be detected which make it highly probable that we have to deal with two different species. In size both forms are very similar, but the Indian shell is a little more elongated in its general outline, the beaks are more pointed and prominent; but the chief difference consists in the posterior hinge area, which is impressed in the Indian fossil in such a manner that the hinge line is not visible in a side-view of the shell, whilst it is roof-shaped in Sowerby's species and bounded on both sides by angular ridges.

Another species which can be compared to *Nuculana sub-acuta* is *Nuc. kazanensis*, Vern. The original figures of this species in the "Geology of Russia" represent two specimens, one internal cast and one impression in the rock, both of rather large dimensions, which can easily be distinguished from the Indian shell, not to speak of their far more considerable size, by their more prominent anterior and narrower posterior dimensions.

Very nearly related to *Nuc. kazanensis*, Vern., as well as to our *Nuc. sub-acuta* is *Nuculana bellistriata*, Stevens, from the coal-measures of Illinois and Nebrasca. In size it approaches more the Indian fossil; but, like *Nuc. acuta*, Sow., it can be distinguished from it by the presence of a roof-shaped posterior hinge area, limited on both sides by prominent angular ridges. *Nuculana bellistriata* has already been described from Spitzbegen by Toula.

Thus the Indian *Nuc. sub-acuta*, W., is related as well to coal-measure as to permian species, but seems to be in less close connection with species from the mountain-limestone.

Family: *NUCULIDÆ.*

Sub-Family: *NUCULINÆ.*

Genus: NUCULA, Lamk.

This genus is one of those which have been most frequently quoted in a fossil state; and chiefly in palæozoic formations it has for a long time been the custom to consider many shells which could not well be determined as belonging to any other genus as forming part of the genus *Nucula*. More recently, however, several other genera have been distinguished, which though allied to *Nucula*, yet are different from it, and thus it has become more easy to make any indications as to the existence of the genus *Nucula*, properly speaking, in geologically older formations.

It remains doubtful whether during silurian times the genus had already existed. It seems to have been represented there by the genus *Tellinomya*, Hall, *Ctenodonta*, Salt., which differs from *Nucula* by the presence of an external ligament.

In devonian strata the genus *Nucula* has already very frequently been quoted, and it seems that some of the species really belong to the genus. Others, however, have been attributed to other genera, of which chiefly *Nuculites*, Conrad (? ? identical with *Cucullella*, M'Coy), and *Palæaneilo*, Hall, are noteworthy. The former is easily distinguishable by an internal ridge which extends in a vertical position just in front of the beak down to near the ventral margin of the shell, so that casts in which the characters of the hinge cannot be observed very much resemble casts of *Cleidophorus*. *Palæaneilo*, H., is very nearly related to *Tellinomya*, H., and only more explicit publications of this author will throw light upon the question as to whether these two genera are really distinct. The external form of *Palæaneilo* is very characteristic and well distinguishable from *Tellinomya*.

Not more largely than in devonian deposits does the genus *Nucula* seem to be represented in the carboniferous period; and it is chiefly in the coal-measures that a somewhat large number of species occurs. By the side of the *Nuculæ* species of *Tellinomya* are still found in the mountain-limestone. In the permian formation the genus is not very rich in species, but very rich in individuals, whilst during mesozoic times everywhere species of *Nucula* are met with, often in very great numbers.

The genus *Nucula* is represented in the palæozoic deposits of the Salt-range by two species, which are both very rare. One of them might possibly best be identified with a species from the American coal-measures, which has been called by Hall *Nuc. ventricosa;* the other species is identical with a shell which occurs in the

permian beds of the country round Kasan, and has been considered by Golovkinsky as belonging to *Nucula beyrichi*, Schaur., which is, however, not identical with Schauroth's species, but has been described by Eichwald under the name of *Nucula trivialis*.

Thus the relations of the species of *Nucula* lie entirely with very young palæozoic species, the coal-measure species occurring originally in the upper coal-measures of Iowa, but it was afterwards detected to occur also in the beds of Nebrasca, which have been considered by very high authorities as belonging to the permian formation, the other having been described originally from the typical permian beds of Russia.

There are exhibited by both the Salt-range species of *Nucula* very striking relations to geologically older forms. *Nucula ventricosa*, Hall, is very nearly related to *Nuc. tumida*, Phill., from Bolland, or not less to *Nuc. unilateralis*, M'Coy, from the mountain-limestone (carboniferous slate) of Lisnapaste; *Nucula trivialis*, Eichw., on the other hand, is with difficulty distinguishable from *Nuc. delta*, M'Coy, the exact geological position and locality of which is not known, but which undoubtedly came from the mountain-limestone of Ireland.

It is thus highly probable that also within the genus *Nucula*, in the sense just indicated, developmental series exist, but it seems to me barely possible to make any direct indication in that direction, without the opportunity of studying in monographical form a greater number of the allied species, for which I have at present neither time nor materials.

1. Nucula ventricosa, Hall, Plate XIX, fig. 20.

1858. *Nucula ventricosa*, Hall: Report, Iowa I, pt. II, p. 716, pl. XXIX, fig. 5 a. b.
1872. *Nucula ventricosa*, (Hall) Hayden: Final Report, Nebrasca, p. 204, pl. X, fig. 17 a. b. c.

The general outline of this little shell is transversely oval, with very excentric beaks, strongly produced in front and truncated behind, the valves very convex.

The beaks are sub-posterior in their position, rather strongly inflated, not much prominent, pointed, and distinctly incurved towards the posterior side. In front of them there is a sloping, elongately oval, tolerably deeply impressed kind of area or lunula, which is, however, not sharply defined, and causes no sinuation whatever in the outline of the shell. The anterior margin is very narrowly rounded and very much produced. It joins the flatly-arched ventral margin without distinct demarcation. The posterior margin is somewhat more broadly rounded and distinctly sinuated just below the beaks. This sinuation corresponds to an excavation of the shell posteriorly just below the beaks, very similar to the lunula of other shells.

The valves are rather inflated, the greatest thickness being situated not quite in the middle of the shell, a little in front of the beak.

The substance of the shell is rather solid.

The hinge apparatus cannot be very distinctly observed. It can only be seen that the hinge consisted of a number of crenulations, the exact number of which can, however, not be stated. The ligamental pit is also not visible.

The surface sculpture of the shell is very characteristic. It consists of very numerous and very fine concentric striæ, only visible with the lens. They are not all equal in strength, some being more strongly expressed, marking larger stages of growth.

The dimensions of the only specimen are as follows:—

Entire length of the shell	8 mm.
„ breadth „	7 „
Thickness of the right valve	2·5 „
Apical angle	98°

Locality and geological position.—The only specimen of this species that has been found up to the present was collected by myself at Virgal in the topmost bed of the upper division of the Productus-limestone, composed of a hard greyish-yellow sandstone. The specimen represents the right valve only.

Remarks.—I was for a long time very much in doubt whether the shell here under consideration had better be united with *Nucula beyrichi*, Schaur., from the German Zechstein, or with Hall's *Nucula ventricosa*, but at last I have decided in favour of the latter opinion. In the first place *Nuc. beyrichi* very rarely grows so large as our specimen, and then it is also always shorter in comparison to its breadth, and the dorsal line anteriorly to the beaks is less impressed. All these characters distinguish the Indian shell from *Nucula beyrichi*, and connect it more or less with *Nuc. ventricosa*. Also the apical angle is somewhat smaller in our shell than in *Nuc. beyrichi*.

In size, in general outline, in the inflation of the valves, the apical angle, and the surface sculpture, our shell is most similar to *Nuc. ventricosa*, and thus, I think, I am justified in uniting the Indian shell with Hall's species.

Of other shells *Nucula tumida*, Phill., from the mountain-limestone is most nearly related. According to the figure, however, that shell seems to grow somewhat larger, and to have a coarse sculpture; also the inflation of the valves seems to be more considerable. *Nucula unilateralis*, M'Coy, from the mountain-limestone of Ireland is also larger, and has the dorsal region of the anterior part of the shell not impressed.

Nucula ventricosa, Hall, occurs in the upper coal-measures of different localities in America, but seems generally not to be very numerous. By Meek it is stated to have been found also in the lower coal-measures of West Virginia.

2. Nucula trivialis, Eichwald, Plate XXIV, fig. 8.

1860. *Nucula trivialis*, Eichw.: Leth. Rossica, Vol. I, part 2, p. 995, pl. XXXVIII, fig. 15.
1869. *Nucula beyrichi*, (Schaur.) Golovkinsky: On the Permian Formation of the Kama-Volga Basin: N. Golovkinsky's—Materials for the Geology of Russia, Vol. I, p. 370, pl. V, fig. 4 (*non* Schauroth).

This very small species is of a very characteristic general outline, nearly triangular in its shape, with tolerably inflated valves.

The beaks are nearly median, slightly posterior in their position, pointed, prominent, and distinctly incurved backwards. In front of them the dorsal margin is strongly inclined, nearly straight, very little arched. The anterior shell margin is tolerably strongly produced and very narrowly rounded. It unites with the flatly-arched ventral margin without proper limit. This latter forms a rounded, nearly rectangular, junction with the posterior margin. Posteriorly the shell is obliquely truncated, the margin being, however, but little prominent, nearly straight, slightly excavated just below the beaks, forming there a kind of small lunula posteriorly to the latter.

The hinge margin is about rectangular, but the number of hinge teeth cannot be observed in the Indian specimen. According to Golovkinsky's drawing, the species had eight such teeth on the anterior part of the hinge line and five on the posterior part, on both sides some teeth less than *Nucula beyrichi*, Schaur.

A peculiarity very characteristic of this species is the apical angle, which is in the Indian specimen as well as in Golovkinsky's drawing not more than 81°.

The substance of the shell is rather solid; the surface sculpture consists of very fine but very regular concentric striæ, which are as if cut in with a knife in the substance of the shell and leave tolerably broad flat spaces between them. There are no more strongly marked stages of growth observable.

The measurements of a specimen from Chidru are as follows:—

Entire length of the shell	6 mm.
„ breadth „	5·75 „
Thickness of the right valve	2 „
Apical angle	81°

Locality and geological position.—The figured specimen of this species was found by myself at Chidru, in a hard yellow sandstone forming the top bed of the upper division of the Productus-limestone. Another specimen (a duplicate) was collected also by myself at Khura, in a hard grey limestone in the upper region of the middle division of the Productus-limestone. According to Golovkinsky's indications the species is not rare in the Government Kasan along the shores of the river Volga, where it occurs in the upper as well as in the lower division of the permian limestone, from which localities the species was originally described by Eichwald.

Remarks.—Golovkinsky was quite right in uniting this shell with *Nucula beyrichi* when he did not wish to acknowledge Eichwald's species. There is but

little doubt that of all species known *Nuc. beyrichi* is most nearly related to the shell here under consideration; on the other hand there are differences observable which make it highly probable that we have to deal with two different species. The fact of such differences had, indeed, been observed by Golovkinsky; but of these he thought the strong development of an anterior (posterior according to his views) muscular impression the only one worthy of notice. I have had occasion to compare the shell here under consideration with a number of well preserved specimens of *Nuc. beyrichi* sent to me by Director Professor Dr. Liebe of Gera for inspection, and I can state that *Nucula beyrichi*, Schaur., is generally distinguishable from the present species by a less triangular outline, less median position of the beaks, the anterior dorsal outline being somewhat more vaulted and the posterior less truncated, and by a much smaller apical angle. The apical angle of *Nuc. beyrichi* is generally 95 to 100 degrees, rarely less, as is shown also by Geinitz's figures, whilst it is in *Nuc. trivialis* 81 to 83 degrees at the maximum. Thus I think the latter species can well be considered as distinct from the shell which is so common in certain beds of the German Zechstein. Nevertheless *Nuc. trivialis*, Eichw., is also a shell characteristic of the permian formation, and it seems to replace the *Nuc. beyrichi* in this formation in the country round Kasan.

Another species, very similar to the present one, is *Nucula delta*, M'Coy, from the mountain-limestone of Ireland. It is, however, easily distinguishable by the flattened, compressed form of its valves and by the smooth surface of its shell.

Family: *ARCIDÆ.*

Sub-family: *ARCINÆ.*

Genus: MACRODON, Lycett.

This genus is one of those which are most largely represented in the fossil state; and most of the shells which have been generally called *Arca*, especially in the older formations, will have to be assigned to the genus *Macrodon*.

It is doubtful whether the genus existed during silurian times, but in devonian strata its presence is beyond doubt, though species belonging to it are not very numerous. So much the more abundant do they appear in the carboniferous formation, and the mountain-limestone has furnished already some dozens of species. From this upwards the genus is continuously represented, and it seems to have attained a second maximum of development in jurassic strata, but in the cretaceous period we find already its last representatives. As far as is known to me no species of *Macrodon* has been detected up to the present in tertiary strata.

A genus very nearly related to *Macrodon*, but which yet must be kept separate, is *Dolabra*, M'Coy. This will be treated of further on in this work.

The genus *Macrodon* is represented in the palæozoic deposits of the Salt-range

by a single species, which shows, however, dimensions rather unusual for a palæozoic species of the genus. In general outline and sculpture it is most nearly related to *Macrodon striatum*, Schloth., sp., of European permian strata, but the two can readily be distinguished. In the carboniferous formation forms like *Macr. lacordaireanum*, Kon., *M. verneuilianum*, Kon., or *M. cancellatum*, Sow., might be compared, but their resemblance to the Indian shell is much less striking. I shall give the name of *Macrodon geminum*, W., n. sp., to the Salt-range species.

1. Macrodon geminum, Waagen, n. sp. Pl. XX, fig. 3.

This is a tolerably large species of transversely oval general shape, very inequilateral, with not very strongly inflated valves, small area and radial sculpture.

The beaks are very excentric in their position, prominent, distant from each other, and distinctly incurved towards the front, not pointed. Below them there extends a rather narrow distinct triangular area, which stretches along the entire length of the straight hinge line. Anteriorly a prominent pointed angle is formed, where the hinge line unites with the anterior shell margin; posteriorly the angle is very obtuse between the hinge line and the posterior margin. The anterior margin of the shell is flatly rounded, and passes without distinct limit into the slightly sinuated sloping ventral margin. The posterior margin is broadly rounded, forming a prominent arch where it unites with the ventral margin.

The substance of the shell has been lost in one of the two specimens I have for description, and only the internal cast is available for observation. In the other specimen parts of the shell are preserved, and it can be stated that its substance was not very solid.

In one of the specimens the impression of the hinge can be partly seen, and from this it appears that on the posterior part of the hinge line there are two horizontal laminar teeth one above the other, the upper one being the smaller. The more or less vertically placed small teeth seem to have commenced already posteriorly to the beaks, and to have extended to the anterior end of the hinge line. As far as can be made out there seem to have been about ten of them.

The valves are not very strongly inflated, and as also the area is not very broad, it is a natural consequence that the beaks are not very far distant from each other. The greatest thickness of the valves occurs anteriorly, directly below the beaks, owing to the presence of a kind of broad low protuberance extending radially from the beak to the ventral margin of the shell. Behind this there is a very low barely perceptible broad depression of the shell, also in a radial direction from the beak to the ventral margin, on which latter it produces a slight sinuation. Posteriorly it is limited by an angular elevation, which shows a distinct declivity on its posterior side, marking off a comparatively flat triangular posterior space of the shell.

The whole surface in the casts is covered by strong radial folds, to the number

of about 24; they take their origin near the beak, and are not augmented by bifurcation in their extension to the ventral margin. They therefore increase very much in size in the vicinity of that margin. All the radiating folds are crossed by rather distant concentric plications, marking larger stages of growth, and producing a sort of swellings where they cross over the radiating folds, in consequence of which the radiating costæ appear coarsely and irregularly nodose.

Though one of the specimens at my disposal is partly and the other entirely an internal cast, yet on neither can anything be seen of the pallial and muscular impressions.

The dimensions of the larger of the two specimens are as follows:—

Entire length of the shell	52 mm.
„ breadth „	32 „
Thickness of the left valve	11 „
Apical angle, about	125°

Locality and geological position.—There are two specimens (both left valves) of this species preserved in the Salt-range collection, the larger of which (an internal cast) was found by Mr. Wynne at Morah in a very hard grey limestone, evidently belonging to the middle division of the Productus-limestone. The other, a specimen with partly preserved shell, was collected by myself at Khura in a thinly-bedded hard grey limestone forming the upper region of the middle division of the Productus-limestone.

The species seems thus to be restricted to this division of the Productus-limestone.

Remarks.—The species which in most characters seems to be most nearly related to the present one is *Macr. striatum*, Schloth., sp., from the Zechstein of Germany, less so is *Macr. tumidum*, Sow., from Tunstall Hill. From both species the present one can easily be distinguished by its larger size, coarser radial folding and smaller area. It is, however, highly probable that *Macr. geminum*, W., is a vicarious form in India for *Macr. striatum*.

Of other shells, that which has been figured by de Verneuil in the Palæontology of Russia under the name of *Arca lacordairiana*, Kon., but which is not at all similar to Koninck's figure, might also possibly be compared to the present species. It has much finer radial folds, which are, however, also slightly nodulose.

Thus it is more or less probable that the species *Macr. lacordairianum*, Vern. (non Kon.), *Macr. striatum*, Schl., sp., and *Macr. geminum*, W., may form a developmental series; but as I have not seen authentic specimens of the first of these species, I cannot decide on the matter. At the same time it is interesting to observe that also in this species the most striking relation lies with European permian species, and that the relation to carboniferous species in Europe as well as in America is a much less close one.

Genus DOLABRA, Mc'Coy.

This is one of the most difficult genera in existence, and the views regarding it that have been taken by different authors are so widely different from each other that it is barely possible to penetrate to a right understanding as to which shells should be properly included in the genus.

The genus was characterised originally by Mc'Coy as follows:—"Sub-rhomboidal, gibbous, slightly inequivalve, inequilateral, anterior side rounded, posterior side subtruncate, generally oblique, shell thick, beaks large, prominent; in the left valve two long, diverging cardinal teeth, anterior one longest, and two lengthened, posterior, lateral teeth." At the same time he says that species belonging to *Dolabra* have been described as *Lyrodon*, *Cucullæa*, *Cypricardia*, &c. The shells which he figures as *Dolabra* are of very distinguishable shapes, and certainly include very different things.

In 1853 de Ryckholt emended the genus *Dolabra* in the second part of his "Mélanges Paléontologiques," but I think in the wrong direction. He considers it identical with his *Tornacia*, and places all the palæozoic shells, which had been previously described as belonging to the genera *Tellinites*, *Tellina*, *Amphidesma*, *Mactra*, *Axinus*, *Sanguinolaria*, in the genus *Dolabra*, within the scope of which according to his definition would thus also fall the genera *Schizodus* and *Myophoria*. Such an emendation of the genus *Dolabra* is decidedly wrong, and involves a mixing up of very different things.

As, however, the genus cannot stand as originally defined by Mc'Coy, an emendation must be attempted, and it will be best to accept the emendation proposed in 1855 by Mc'Coy himself in his "British Palæozoic Fossils," and which in very radical points differs from the original characteristic of the genus. According to the definition given there, the shells belonging to the genus possess a flat narrow ligamental area, extending over the whole length of the hinge line, and "one thick elongate posterior lateral tooth or cardinal ridge in each valve, inclining at an acute angle from the hinge line, that of the left valve, sometimes bifid; pallial scar entire."

According to this definition the shells belonging to the genus would greatly resemble the *Arcidæ*, chiefly the genus *Macrodon*, and their position in the *Salemyidæ*, as advocated by Stoliczka, is even more than doubtful. It is, however, on the other hand certainly going too far to unite *Dolabra* entirely with *Arca*, *Cucullæa*, or even *Macrodon*, as forming one and the same genus. Though a general relation to the genus *Macrodon* cannot be denied, there yet exists a very great difference in the absence of the small hinge teeth anterior to the beaks. The same difference exists also between *Dolabra* and the genus *Cypricardites*, Conr. (=*Palæarca*, Hall), though chiefly the Australian species belonging to this latter genus are rather similar to the Indian species of *Dolabra*. The presence of an area for the

attachment of the ligament combined with the other characters make it highly probable that we have to consider *Dolabra* as a genus belonging to the family *Arcidæ*.

I shall describe two species from the Salt-range as belonging to the genus, but of neither of which is it certain whether it really belongs to the genus. Of one of these shells the hinge is not known, and this one is assigned to the genus solely on account of its external characters (comparatively thin structure of the shell and small area). In the other species the hinge is tolerably well visible, but the elongated posterior tooth cannot be well observed. Both species, however, agree very well, in general outline and the very small ligamental area, with the greater number of the shells described under Mc'Coy's genus.

The geological distribution of the genus cannot even approximately be stated, as species belonging to it are mostly quoted under other generic designations.

1. Dolabra arcina, Waagen, n. sp. Pl. XIX, fig. 21.

This little shell has an elongated oval shape, little prominent beaks, a straight hinge line, and tolerably inflated valves.

The beaks are sub-anterior, rather obtuse, distinctly incurved, very nearly contiguous. The hinge line is straight, extending over the greater part of the length of the shell. The anterior margin of the shell is obtusely rounded, and joins the hinge line at nearly a right angle. The ventral margin is flatly arched, not distinctly separated from the anterior and posterior margins. The latter is also rounded, but more narrowly than the anterior one, and joins the hinge line under a very obtuse angle.

Below the beaks, along the hinge line there extends a very narrow flatly triangular area, but it is not certain whether it served for the insertion of a ligament as is the case in the *Arcidæ*. The manner in which the ligament may have been fixed cannot be observed.

The hinge itself is not visible.

The surface of the shell is flatly arched, the greatest thickness of the valves being situated below the beaks in the anterior part of the shell. There is no surface sculpture observable, except very fine and distant concentric striæ of growth.

The substance of the shell is not very solid, but tolerably so.

The dimensions of the only specimen are as follows:—

Entire length of the shell	15 mm.
„ breadth „ „	9·5 „
Thickness of both valves	5·5 „
Apical angle	142°

Locality and geological position.—There is only one specimen of this species in the Salt-range collection; it was found by myself in the grey micaceous sandstone

of the Níla Wán, which constitutes there the lower division of the Productus-limestone.

Remarks.—Though the generic position given to this shell is not quite certain, yet it is the most probable one. The only genus to which it might also possibly be assigned is *Arca* or some allied genus, but in these genera the area is very rarely so small as in the shell here described; the shell of the species here under consideration is moreover somewhat too thin for an *Arca*. But the two characters just indicated are characteristic for *Dolabra*, and thus the position of this fossil in Mc'Coy's genus is, I think, perfectly justifiable.

As to species, it is very difficult to find out whether there is any nearly related to the form here described. Among the shells which have been called *Dolabra* by former writers, there is none which could be compared to our shell, but under the different species of *Arca* or *Cucullæa* there may well be more or less allied forms. *Arca faba*, Kon., for instance, is very likely a *Dolabra*, and in its general form not dissimilar to our *Dol. arcina*, but it can easily be distinguished by the concentric sulcation on its surface. Of other species the generic position is too doubtful to allow of a closer comparison with the species here under consideration; only *Palæarca interrupta*, Kon., from Australia might yet be mentioned. It is about of the same size as our Indian fossil, but more elongated in its general outline, and bears a concentric folding which is absent in the Indian shell.

2. Dolabra corbina, Waagen, n. sp. Pl. XXIV, fig. 6.

The general outline of this rather small species is somewhat quadrangular, truncated in front and behind, the hinge line is straight, the valves inflated.

The beaks are nearly median in their position, very little prominent, pointed, inflated, and distinctly incurved towards the front. When the valves are in juxtaposition it seems that the beaks nearly touch each other. Below the beaks a very small elongated triangular area is present for the attachment of the ligament; it extends the whole length of the hinge line. The hinge line is quite straight and about as long as the entire shell. Anteriorly it joins the anterior shell margin in forming a rounded angle of about 90 degrees. The anterior margin is nearly straight, barely at all curved, and so is the ventral margin; they meet in forming an obtusely rounded angle. Also at the point of junction between the ventral and posterior margins an obtuse angle is formed. The posterior margin is somewhat more curved than the anterior one, and unites with the hinge line in a gentle curve.

The substance of the shell is tolerably solid; nevertheless it has not been possible to clear the region of the hinge from the adhering rock. All that could be observed is that anteriorly to the beak the hinge margin is smooth, not crenulated. The ligament commences a short distance in front of the beak, and its extent can

be distinctly traced by a sharp groove, which served for its insertion, and which runs along the whole posterior part of the area. The mode of insertion of the ligament is very much like that occurring in *Deoarca*. The rock is too hard to admit of the characters of the hinge being traced any further; but in one of the specimens, the largest, it seems as if there were an elongated laminar posterior tooth parallel to the hinge line.

The pallial and muscular impressions could not be observed.

The surface of the shell is rather strongly vaulted. From the apex to the lower posterior corner of the shell there extends in two of our specimens an indistinct angular ridge, marking off a posterior triangular space of the shell; in the third specimen this ridge is obliterated. The greatest thickness of the valves is about in their middle. The whole surface of the shell is covered by very numerous and very fine concentric striæ of growth, which at intervals form strong imbricating folds, marking larger stages of growth.

The dimensions of a middle-sized specimen from Chidru are as follows:—

Entire length of the shell	13 mm.
„ breadth „ „	11 „
Thickness of the right value	6 „
Apical angle, about	125°

The largest specimen found up to the present is not entire; but it seems to have been about 25 mm. in length and 18 mm. in breadth.

Locality and geological position.—There are altogether three specimens of this species preserved in the Salt-range collection, all three right valves, found by myself at Chidru, in a hard yellow sandstone forming the top bed of the upper division of the Productus-limestone.

Remarks.—Nothing seems to be more difficult than to fix the genus to which the present shell ought to be assigned. For a long time I considered *Unicardium* as the proper designation for it, but after I had ascertained that the ligament was not supported by fulcra, but attached to a kind of area, it was evident that *Unicardium* could not any longer be taken into consideration. Of all the other genera only *Dolabra* would fit at all, and thus I have placed the present shell in Mc'Coy's genus.

There is quite the same difficulty in regard to the shells to which the present species can be fitly compared. A shell which exhibits really a very great similarity to our *Dolabra corbina* is *Panopæa mackrothi*, Gein., from the "Weissliegenden" of Tieschitz near Gera. The difficulties as to the generic classification of this shell have all been pointed out by Geinitz, and he states that certain specimens show as much affinity to *Arca* as to *Unicardium*, and that the position in the genus *Panopæa* is only a provisional one. So long as the muscular and pallial impressions of this species are not known, its position in the genus *Panopæa* seems to be very questionable. If we compare this *Panopæa mackrothi* with our *Dolabra corbina*,

the two shells agree in the squarish outline of the valves, the median position of the beaks, a tolerably straight or little arched hinge line, and the great inflation or convexity of the valves. Besides these characters the specimen figured in Geinitz's Dyas (Pl. XII, fig. 22) exhibits also an angular ridge extending from the apex to the lower posterior corner, and marking off a posterior triangular space of the shell. The two species differ from each other by the more considerable size of *Panopæa mackrothi* and by its regular concentric striation. On the whole it seems probable that *Dolabra corbina*, W., is the representative, the vicarious species, of *Panop. mackrothi* in the palæozoic deposits of the Salt-range.

Of mountain-limestone and older palæozoic species none is known to me which could be particularly compared to the present species. So much the more interesting is it to observe how this species exhibits so very near a relation to a shell occurring in the permian formation of Europe.

Order: MYTILACEA.

Family: *MYTILIDÆ.*

Sub-Family: *DREISSENINÆ.*

Genus: SEPTIFER, Recluz.

There is nothing surprising in the occurrence of a member of the sub-family *Dreisseninæ* in the palæozoic deposits of the Salt-range; as it is well known, that already in the devonian period shells occur, which beyond doubt belong to the present sub-family, and which have received from Sandberger the name of *Hoplomytilus*.

It is somewhat more unexpected to find the genus *Septifer* represented in these deposits. The geologically oldest species that can be attributed to the genus is *Mytilus eduliformis*, Schl., from the European Muschelkalk, unless *Mytilus comptus*, Mc'Coy, from the mountain-limestone of Ireland has to be considered as a representative of the genus. The former species according to Giebel's drawing exhibits very clearly the internal plate which serves for the insertion of the anterior adductor and the sinuation and incurvation of the anterior ventral margin, characteristic of the genus; but the radial striation and the crenulated margins as well as the cardinal teeth, which are mostly present in *Septifer*, are absent in the triassic shell. As long as no more species are known in which the hinge has been observed so distinctly as in *Myt. eduliformis*, it will barely be possible to indicate whether the differences just pointed out are sufficient for the distinction of a new genus, and thus it will be better for the present to retain Schlotheim's species in the genus *Septifer*.

The generic position of *Mytilus eduliformis*, Schloth., is of great importance in the present case, as the shell which I have to describe from the Salt-range is very nearly related to that species, and as all the characters of the hinge cannot be

distinctly made out, it is chiefly the affinity to *Myt. eduliformis* which must decide its generic position.

As has been noted above, the radial sculpture, which is present in most species of *Septifer*, is absent in *Myt. eduliformis* as well as in the Indian shell. According to the presence or absence of such sculpturing two sections can be conveniently distinguished within the genus, the one devoid of radial sculpture might be termed "*Læves*," and the one on which the sculpture is present might bear the name "*Radiata*."

The Indian shell belongs to the first of the two.

Section I: LÆVES.

1. Septifer squama, Waagen, n. sp. Pl. XXIV, fig. 7.

The general shape of the shell is elongately oval, angular on the top, and broadly rounded below. The beaks are perfectly terminal and pointed, little incurved. The ligamental area is short and slightly curved. It unites in a gentle arch with the dorsal margin, which descends in a low curve to meet the returning curve of the ventral margin of the shell. This latter is strongly bent inward immediately below the apex, but very soon turns out again and forms a prominent arch, descending thus to the lower or posterior margin, which joins the dorsal margin in a rather narrow curve. The excavation of the shell thus formed below the beak is deep but very short, and extends to not even half the length of the shell.

The valves are flatly arched, only the ventral excavation is surrounded by an obtuse ridge. The surface of the shell is covered by somewhat scaly imbricating striæ of growth, which are, however, only well visible near the margin.

The whole shell is strongly compressed and flattened, and the transverse diameter of both valves is only one-third of the entire length of the shell. The greatest transverse diameter is situated quite near the apex, only one-sixth of the length of the shell distant from it.

The shell is of rather thin structure.

The measurements are as follows:—

Greatest length of the shell	25 mm.
„ breadth „ „	16 „
Thickness of the left valve	3·5 „
Apical angle	73°

Locality and geological position.—The only specimen of this species in the Salt-range collection was taken out of a piece of light greyish-yellow sandstone, brought by Mr. Wynne from Khund Ghát. It contained also a specimen of a large *Streptorhynchus*, and comes certainly from the upper division of the Productus-limestone formation. Very likely this sandstone is among the highest beds of this division.

Remarks.—The position of this shell in the genus *Septifer* is not above every doubt, as I have been unable to clear its entire hinge line from the adhering rock; but as far as it could be inspected it seemed not to possess the characteristic grooves of *Myalina*. Moreover, the strong inflection of the anterior ventral margin speaks very much in favour of *Septifer*.

In its general form this species resembles two different palæozoic fossils. First it has a certain likeness to *Mytilus comptus*, Mc'Coy, from the carboniferous-slate of the yellow-sandstone group below the mountain-limestone of Ireland, which species also might be a *Septifer*. This species is, however, distinguishable from the Indian fossil by its more slender and more curved apex and by its more broadly rounded inferior or posterior margin.

The other species with which the present one can be compared is *Mytilus squamosus*, Sow. (= *Mytilus hausmanni*, Godf., = *Aucella hausmanni*, Gein.), from the permian strata of England, Germany, and Russia. In this case, however, the similarity is only an external one. I have, for comparison, quite a number of very excellent specimens of *Mytilus hausmanni*,—thanks to the great kindness of Professor Liebe in Gera; but to judge from these specimens this shell can be neither a *Mytilus* nor a *Septifer*, nor an *Aucella* nor a *Myalina*. It cannot be a *Mytilus* or a *Septifer*, because the ligamental area is not a simple line for the attachment of the ligament, but is provided with pits as in *Gervillia*. It cannot be an *Aucella*, because a byssal sinus in the smaller right valve is absent, and it cannot be a *Myalina* on account of the absence of the longitudinal grooving of the ligamental area which is characteristic for that genus. The only genus with which this very strange form of shell could possibly be counted is *Mytiliarca;* but this position also seems not to be tenable, and it will be necessary, as will be done further on in this work, to create a new genus for the reception of this shell. On a first glance it is evident that the hinge of the Indian *Septifer squama* is quite different from that of *Mytilus hausmanni*, and thus the similarity of form of the two shells is only apparent. But also externally the two species can be distinguished without difficulty. The Indian shell is much more rounded in outline and deeply excavated on the ventral side which is not the case in *Myt. squamosus* or *hausmanni*.

A much greater similarity than to any palæozoic species is exhibited by the shell here under consideration to *Septifer eduliformis*, Schloth., from the Muschelkalk of Germany. If we compare the two shells as to their external characters, we find that only very trifling differences exist, and that it is rather doubtful whether, if more extensive materials were procurable, the Indian shell could yet be considered as forming a species different from that of the German Muschelkalk.

In the Indian fossil the beak is somewhat less pointed, the sinuation of the anterior part of the ventral margin is somewhat less strong, and thus the whole shape of the shell somewhat more regularly triangular and somewhat broader in comparison to its length. All other characters are perfectly identical, and thus it

may be presumed that also the characters of the hinge, which cannot all be observed in the Indian shell, agree to a certain extent. As, then, these characters in *Mytilus eduliformis*, Schl., are of such a nature that this shell must be considered as belonging to the genus *Septifer*, it is also more than probable that the Indian shell belongs to this genus.

That in the palæozoic deposits of the Salt-range a shell should occur which even specifically can barely be distinguished from a species of the German Muschelkalk, is certainly a fact of great geological importance.

Sub-family: *CRENELLINÆ.*

Genus: LITHODOMINA, Waagen, n. gen.

The sub-family *Crenellinæ* is, according to Dr. Stoliczka, characterised by a thin shell, tumid valves, and a quite internal ligament, which is lodged in a linear groove, extending posteriorly along the hinge line, and by two distinct muscular impressions. Besides these characters there occurs in recent species generally a radial striation covering entirely or partly the surface of the shell, and a denticulation of the hinge line on its posterior part. These latter characters do not occur in all the genera or species belonging to the sub-family, and thus they cannot be considered as indispensable for the reference of a genus to the sub-family.

The shells which I shall describe under the name of *Lithodomina* agree with the sub-family *Crenellinæ* in the thin shell, the quite internal ligament, which is lodged in a linear groove parallel to the posterior hinge line, and the tumidity of the valves. The rather great development of the anterior part of the shell is also suggestive of an anterior muscular impression, though this has not been observed up to the present. For these reasons I consider it not quite improbable that these shells should belong to the sub-family *Crenellinæ*.

I was a long time in great doubt what should be done with the shells here under consideration. In general outline they most approach certain shells, which, in palæozoic strata, have mostly been described in the genus *Nucula*, but which are now attributed to different other genera, all however belonging to the *Nuculidæ*. In the shells here under consideration the crenulations of the hinge line characteristic of the *Nuculidæ* are decidedly absent, and thus there can be no question of these shells being *Nuculidæ*.

The very elongated form exhibited by some of these shells seemed then possibly to indicate a relationship to the *Solenidæ*, and as two muscular impressions seem to be present, a relationship was not quite out of the question. There is, however, not a trace of a sinuation in the pallial impression observable, the hinge is absolutely toothless, and thus these shells cannot belong either to the *Solenidæ*.

A similarity of the external form, which is very striking, exists also to *Solenocaris* of Meek, a genus which is considered to belong to the phyllopodous crustaceans. Similar as the external forms may be, there is yet one character absent in

the Indian shells, which is very characteristic for *Solenocaris;* this is a very singular sculpture of the shell. The same character ought to be present if the Indian shells were *Entomostraca;* either the shell or the cast ought to show certain furrows, which might be microscopical, but which ought to be present. As my materials were not sufficient to make microscopical preparations, some doubt remains whether we have not to deal here with *Entomostraca*, but the whole appearance of the shell, the characters of the hinge, and the singularly flattened appearance of the beaks make it more probable that these fossils are bivalved shells, and among these the only group to which they can belong is the *Mytilidæ*. Every doubt would immediately be removed if pallial and muscular impressions were distinctly observable, but, as is generally the case in such thinly shelled fossils, these impressions are very indistinct, and it remains doubtful whether the marks, which are observable, belong to these organs.

The shells which I consider to belong to the genus *Lithodomina* are more or less elongate, equivalve, very excentric, with subanterior beaks, little developed anterior part of the shell and very elongated posterior part, and with nearly parallel dorsal and ventral margins. The beaks are singularly flattened as in *Lithodomus*.

The hinge is edentulous. Along the hinge line extends a long, not very deep, furrow for the insertion of an internal ligament. There seem to be two muscular impressions, between which an entire pallial line seems to extend, but no distinct observation on this point is possible.

The structure of the shell is very thin, devoid of every kind of sculpture and, if well preserved, shining smooth. Only with a strongly magnifying lens very fine distant striæ of growth are observable.

From all these characters it appears that the shells belonging to *Lithodomina* are most nearly related to *Lithodomus*, the chief difference consisting in a more strongly developed anterior part of the shell, which is very likely coincident with a stronger development of the anterior adductor. In this respect these fossils resemble the *Crenellinæ*, with which they appear also to be related by the nearly internal elongated ligament.

Of the geological distribution of the genus very little can be told. A shell which very likely belongs to the genus is *Nucula cardiiformis*, Eichw., which has been excellently figured in the geology of Russia. If this shell were a true *Nucula*, traces of the hinge teeth would be visible in the cast, but according to the impression of the hinge on the cast it seems to have been edentulous, as has also been observed by de Verneuil. Besides this the nearly parallel dorsal and ventral margins make the position of this shell in the genus *Lithodomina* very probable. This species has been found in the mountain-limestone, and is apparently the oldest that is known up to the present.

Another species, which, from the strong development of the anterior part of the shell, also very likely belongs to the genus here under consideration, is *Lithodomus priscus*, Giebel, from the Muschelkalk of Lieskau.

In India the genus is represented by two species, one of which approaches in its general outline more to the *Nucula cardiiformis* of Eichwald, the other is more similar to *Lithodomus priscus* of Giebel. They occur together in the topmost beds of the upper division of the Productus-limestone.

1. LITHODOMINA TYPA, Waagen, n. sp. Pl. XVIII, figs. 8, 9.

The general outline of this species is very elongated, very excentric, with tolerably inflated valves and shining smooth shell.

The beaks are subanterior in their position, very little prominent, inflated, flattened, and but little incurved forwards. In front of them there is a very small, not very deep, lunula; it is not sharply defined from the rest of the shell, but produces a very distinct and deep sinuation in the outline of the shell in front of the beaks. The anterior part of the shell is distinctly prominent, narrow, and limited by a narrowly curved parabolic margin. The ventral margin is very flatly arched, nearly straight, and is not distinctly limited either anteriorly or posteriorly. The posterior margin forms a somewhat broad parabolic outline, and is joined abruptly by the dorsal margin, which is very long and quite straight parallel to the ventral margin; in some specimens it is a very little impressed along the hinge line.

The hinge is quite edentulous. The hinge line is straight, and a very little thickened posteriorly to the beaks. There extends a long and shallow furrow along this thickened part for the reception of a ligament, which seems to have been sub-internal.

The valves are rather strongly vaulted, being thickest in the dorsal region a little posterior to the beaks.

The substance of the shell is very thin, the surface shining smooth; very fine, not numerous, striæ of growth are only observable with the lens.

The measurements of an entire specimen from Chidru are as follows:—

Entire length of the shell	18 mm.
„ breadth „ „	65 „
Thickness of the right valve	4 „
Apical angle	142°

Locality and geological position.—There were originally three specimens of this species in the Salt-range collection, one of which I have broken in trying to clean the hinge from the adhering rock. There were two right valves and one duplicate, all found by myself at Chidru in the hard yellow sandstone forming the top bed of the upper division of the Productus-limestone.

Remarks.—This species is in general form not dissimilar to *Lithodomus priscus*, Giebel, from the Muschelkalk of Lieskau. The differences of the two species consist chiefly in the broader anterior part and more pointed apex of the triassic fossil.

Of palæozoic species none is known to me which could be in particular compared to the present species.

2. LITHODOMINA ABBREVIATA, Waagen, n. sp. Pl. XVII, fig. 10; Pl. XXIV, fig. 12.

The general outline of this shell is elongately trapezoidal, with a very short truncated anterior and an elongated posterior part. The valves are rather compressed.

The beaks are nearly quite anterior in their position, not prominent, pointed, distinctly flattened, and little incurved. There is a small indistinct lunula in front of them which causes a slight emargination in the outline of the shell. The anterior shell margin is barely at all prominent, broadly rounded, and unites without proper limit with the nearly staight ventral margin. The posterior margin is not very broadly rounded, the dorsal margin is slightly arched, and on the whole about parallel to the ventral one.

The shells belonging to this species are, however, a little variable in their general outline. Sometimes the whole shell is more elongated in comparison to its breadth, sometimes it is shorter. In some specimens the breadth increases from the anterior towards the posterior part of the shell, sometimes it decreases in the same direction, so that sometimes the greatest breadth of the shell is situated near the apex, sometimes it is near the posterior end of the shell.

The hinge of this species is tolerably well visible. There are no teeth of any kind below or near the apex. Behind the apex there commences along the hinge margin a slight furrow, limited on its lower side towards the posterior end of the hinge line by a lamellar shelly ridge, which is, however, barely strong enough to be considered as a sort of tooth. This furrow has evidently served for the insertion of a ligament, which was partly internal.

Of pallial and muscular impressions only very indistinct traces can be seen.

The substance of the shell is very thin. The surface is shining smooth if well preserved, only with the lens are distant fine striæ of growth observable.

The dimensions of a specimen from Chidru are as follows:—

Entire length of the shell	12 mm.
„ breadth „ „	7 „
Thickness of the right valve	2 „
Apical angle	100°

The species seems not to become much larger.

Locality and geological position.—There are three specimens, all right valves, preserved in the Salt-range collection; they were found by myself together with the preceding species at Chidru in the yellow hard sandstones forming there the top bed of the upper division of the Productus-limestone.

Remarks.—There is a remarkable similarity between this species and ***Nucula cardiiformis***, (Eichwald) Vern. The only difference at all apparent consists in the somewhat greater inflation of the valves of the Russian species. The figure, Pl. XVII., fig. 10, which is rather badly executed, does not exhibit this striking similarity; it is drawn from a rather elongated variety, not quite intact at

its posterior end, and therefore appears to have a strange oblique truncation, which is not observable in other specimens.

The specimen figured in Eichwald's Lethæa Rossica seems to be different from the fossil figured by de Verneuil under the name of *Nucula cardiiformis*, and might be a true *Nucula*. It is only to de Verneuil's drawing that there is a similarity in our *Lithodomina abbreviata*, but I did not venture to unite the two fossils specifically; first there seem to be real differences, such as the greater inflation of the valves and somewhat shorter general outline in the Russian shell; and as I have not been able to examine de Verneuil's original specimen, it is impossible to tell whether this fossil may be identical with our Indian species; so I have preferred only to indicate their resemblance.

Sub-family: *MYTILINÆ*.

Genus: LITHODOMUS, Cuvier.

This genus is not easily recognised in a fossil state, and it seems to have escaped notice to a great extent in deposits belonging to the older formations. The geologically oldest species which I find quoted occur in the carboniferous formation, but in these strata already about four or five species have been noticed. It would thus seem highly probable that the existence of the genus dates further back in the series of formations, and that it has been overlooked on account of the but little prominent characters exhibited by these shells.

The chief features that may be used to recognise the genus are the smoothness and thickness of the shell, the nearly terminal and sometimes flattened beaks which are well incurved, and the nearly parallel upper and lower margins of the shell in the typical forms.

Among the living species of the genus two groups of forms can be distinguished, the one containing the typical shells, with nearly parallel upper and lower margins, the other, more modioliform and only with difficulty distinguishable from *Modiola*, has been separated by Mörch as a separate genus *Botula*.

Both these groups seem to have been represented already among the oldest species of *Lithodomi* that are known to exist. To the first, genus *Lithodomus* in a restricted sense, *Lithodomus jenkinsoni*, Mc'Coy, from the carboniferous-limestone of Lowick seems to belong, and also *Lithodomus pertennis*, Meek and Worthen, from the St. Louis limestone of Illinois.

A second group (? representing the genus *Botula* of Mörch) appears to be indicated by Mc'Coy's *Lithodomus dactyloides* from the carboniferous-limestone of Millicent. Though the general shape of this species is somewhat modioliform, yet the perfectly terminal position of its apex seems to warrant its being placed in the genus *Lithodomus*. The position of Phillips' *Modiola lingualis* in the genus, as has been advocated by American writers, is somewhat more doubtful. If it be a *Lithodomas*, it will probably have to be placed in the sub-genus *Botula*.

The genus seems not to have been observed as yet in permian rocks, but there is little doubt that species belonging to it did exist during that period.

From the trias upwards species of *Lithodomus* recur sparingly in every formation, but never more numerously than in the present seas.

In the palæozoic strata of the Salt-range there occurs but one species, which is, however, well characterised by its smooth shell, not very thin, its terminal apex, and the parallel upper and lower margins. The species shows no affinity to any of the hitherto described species of *Lithodomus* from palæozoic strata.

1. Lithodomus atavus, Waagen, n. sp. Pl. XX., fig. 13.

There is but one valve of this species in the Salt-range collection, and even this is not entire, but what remains of it is highly characteristic, and sufficient to fix the species.

The general form of this shell is elongated oval, narrow, but little inflated, thickest about in the middle of its length. The beak is nearly quite terminal, little incurved and barely at all prominent, with a very small lunula below and in front of it; anterior margin narrowly rounded, almost imperceptibly prominent in front of the beak; posterior margin not preserved; dorsal margin straight; hinge edentulous; ventral margin very slightly convex, about parallel to the dorsal one. Shell of thin structure, with a shining surface and indistinct distant striæ of growth.

The measurements are as follows:—

Entire length of shell, about	23 mm.
Breadth of shell (from dorsal to ventral margins)	7 „
Thickness of the right valve	5 „
Apical angle, about	93°

Locality and geological position.—The only specimen of this species in the Salt-range collection was found by myself in the uppermost beds of the Productus-limestone just below the base of the Ceratite formation at Chidru. It consists of a fragment of the right valve only.

Remarks.—As to the position of this species in the genus *Lithodomus*, there can be no question whatever. Specifically the shell can be barely compared to any palæozoic species; the only form of these showing a slight similarity is *Lithophagus pertennis*, M. & W. Like the Indian species, this one has a straight dorsal and a slightly convex ventral margin, but these margins are divergent in the American shell, whilst they are parallel in the present species. Thus the greatest breadth of the American species is near the posterior end of the valves, whilst it is about central in the Indian fossil. A somewhat more close resemblance to the species here under consideration is exhibited by *Modiola macadami*, Portl., var. *angusta*. It might be questioned whether this very peculiar form is only a variety of the typical species, or whether it is not in reality a *Lithodomus;* there is no doubt, however, that in its general outline it is most similar to the Indian shell. But the

surface sculpture, as described by Portlock, is sufficient to distinguish it from *Lithodomus atavus*, W., and bring it into closer connection with the typical form of *Modiola macadami*, Portl.

Of triassic species there is none known to me which could be particularly compared to the present species.

Genus: MODIOLA, Lamark.

This is a genus which in general is not very difficult to be recognised, though transitional forms to other allied genera exist in rather great numbers; this is also a reason why it seems rather difficult to fix at what horizon the genus made its first appearance. It is rather doubtful whether true *Modiolæ* existed during silurian times. In devonian strata the genus is beyond any doubt represented by typical species, and from this formation upwards they increase constantly in numbers until reaching their maximum of development about in the present period.

Like the recent species, so are also the fossil ones often found in great numbers together, but there are also many solitary forms, and even the greater number of fossil species seem to have been solitary and not gregareous.

The geologically older species of the genus are generally of very moderate size, whilst in the mesozoic formations the single individuals of *Modiolæ* seem to reach their maximum development in size.

During carboniferous times the number of species of *Modiola* is already rather large, but in permian strata the genus seems to become again very scarce. Golovkinsky figures a species of *Modiola* out of permian beds near the Volga. This is, however, not a typical shell, but might rather belong to *Lithodomus*. Also in the Muschelkalk the genus is yet rather rare, but from the lias upwards great numbers of it appear.

In the palæozoic strata of the Salt-range there is only one species which can with all certainty be attributed to the genus *Modiola*.

1. Modiola transparens, Waagen, n. sp. Pl. XX, fig. 11.

This is a medium-sized species with a very thin transparent shell.

The general form is elongated oval, with a straight ventral and an arched dorsal margin. The greatest breadth is in the last third of its length. The shell is moderately inflated, with small, little incurved, and little prominent beaks. In the specimen which serves for description there seems to run down from the apex to the posterior end of the ventral margin a prominent angular ridge; this is, however, only caused by the state of preservation, the shell having been subjected to a pressure which caused the beaks to be flattened and gave rise to this ridge. The beaks are strongly anterior, but not quite terminal, showing a very small, indistinct lunula in front of them.

The anterior margin is well rounded and slightly projecting. The posterior part of the shell is very produced and terminates in a somewhat truncated posterior margin, which forms a distinct obtuse angle with the ventral margin of the shell, but unites with the dorsal margin in a well-rounded curve.

The hinge line is arched, but there is no place visible for insertion of the ligament.

The greatest thickness of the shell is situated not far behind the beaks.

The structure of the shell is glassy thin, with a smooth shining surface, and very thin, regular, but indistinct striæ of growth.

Muscular impressions and pallial line are not visible.

The dimensions of a specimen are as follows:—

Total length of shell, about	41 mm.
Greatest breadth of shell	19 „
Thickness of both valves	11·5 „
Distance of the apex from the anterior margin	3 „
„ „ „ posterior margin	38 „
Apical angle	136°

Locality and geological position.—Two specimens of this species were collected by myself at Jabi in the upper division of the Productus-limestone, in the same bed in which *Cyclolobus oldhami* was found.

Remarks.—This species, though not very remarkable in its form, is yet not very difficult to distinguish from other similar species. The nearest ally to it seems to be *Modiola teplofi*, Vern., out of carboniferous strata of the Donez. It is, however, easy to distinguish this species from the Indian shell by its concave ventral margin, its straight hinge line, and the angular junction of the dorsal and posterior margins. Of other species none can be particularly compared.

Genus: MYTILUS, Linn.

This genus is one of those which are most frequently quoted from all the fossil-bearing formations, but of which nevertheless the geological distribution is very uncertain up to the present.

This uncertainty arises chiefly from the imperfect knowledge of the hinge in most species, which makes an exact generic determination of these shells absolutely impossible.

Already in silurian rocks species of *Mytilus* are quoted, and in the devonian not less than 25 species are said to occur, but of all these it is more than doubtful whether they are really *Mytili*, and not rather *Myalinæ*, of which the hinge is imperfectly known.

From carboniferous strata there appear altogether 38 species of *Mytilus* in Bigsby's tables. Most of these are *Modiolæ;* but some might be really *Mytilus*, as *Myt. comptus*, Mc'Coy, *flemingi*, Mc'Coy, or *Myt. triangularis*, Sow.; of none

of them is the hinge well known, and thus always some doubt exists, as in shape they might be as well *Myalinæ* if the longitudinal grooving of the hinge area were traceable.

It is therefore of interest to note that in the palæozoic strata of the Salt-range, there exists an undoubted species of *Mytilus*, showing all the characters of the recent species. It exhibits the thick tooth-like tubercle below the beak as many recent species do, the dorsal margin is simple without a trace of longitudinal grooves.

The Salt-range strata must certainly now be counted among the higher divisions of the palæozoic formations; and thus we can say that the genus *Mytilus* takes its origin during palæozoic times, though the existence of the genus during palæozoic times is denied by American authors.

1. Mytilus patriarchalis, Waagen, n. sp. Pl. XX, fig. 12.

The shell which served for the description of this species is of moderate size and more or less triangular shape.

The beaks are anterior and quite terminal, somewhat flattened, little incurved. The dorsal shell margin is rather long and slightly arched. Below the apex there is an oblique, thick, rounded, tooth-like prominence, which extends from the apex to the inner anterior margin of the shell. The anterior and ventral margins are quite united, and no limit can be drawn between them. They form together a slightly excavated arch, producing a long and rather broad, but not very deep, kind of lunula below and in front of the beak. In the upper part of this ventral excavation immediately below the beak there is a slight protuberance, indicating the position of the anterior shell margin.

The dorsal margin unites without forming any angle with the posterior margin, which bends round in a low arch to meet the ventral margin forming with it a more narrow curve.

Thus results the more or less triangular shape of the shell, in which, however, only the angle at the apex is acute, the others being rounded off.

The ligament was sub-interior, and lodged in a barely perceptible line along the dorsal shell margin.

The shell is rather inflated, as the transverse diameter of both valves is only a little less than half the length of the entire shell.

The surface is smooth, and even with the lens no striæ of growth can be observed; these, however, might have been rubbed off or obliterated by the process of fossilisation.

The substance of the shell is tolerably thick and compact.

The measurements of the only specimen are as follows:—

Greatest length of shell	25 mm.
„ breadth „ „	14 „
Thickness of the left valve	5 „
Apical angle	53°

The figured specimen was complete originally, but in trying to clean the hinge from the adhering hard rock it was broken, and the lower half could not be saved; so the figure is incomplete.

Locality and geological position.—The only specimen of this species in the Salt-range collection was found by myself at Chidru in a bed of hard sandstone forming the topmost band of the upper division of the Productus-limestone formation.

Remarks.—Though of none of the species of *Mytilus* described up to the present from palæozoic formations has it been shown that the hinge agrees with the typical forms now living, yet there are some species which in their outward appearance so closely resemble the shell here described that a comparison is unavoidable.

There must be mentioned before all *Mytilus triangularis*, Sow., from the carboniferous-shales of Coalbrook Dale. This species agrees almost perfectly in shape with the Indian shell; also the size is nearly the same; but the ventral portion of the shell is not excavated, and the beak is less terminal; so the Indian form cannot be united with it.

Of other species *Mytilus flemingi*, Mc'Coy, might also possibly be compared, but its similarity to the Indian *Mytilus patriarchalis*, W., is already more remote.

The occurrence of a typical species of *Mytilus* in the upper division of the Productus-limestone of the Salt-range gives a rather recent character to the pelecypod fauna of these deposits. Up to the present typical *Mytili* have only been stated with full certainty to occur in secondary formations, and thus it must appear somewhat unexpected to find a species in the Productus-limestone.

Of triassic species, *Myt. cristatus*, Seebach, sp. is not quite dissimilar, but can easily be distinguished by a broad distinct posterior wing, and a straight ventral margin.

Genus: ATOMODESMA, Beyrich.

In 1863 Beyrich described two species of a bivalved shell in the "Abhandlungen der k. Academie der Wissenschaften zu Berlin" under the generic name of *Atomodesma*, of which he gave a very short characteristic, to the effect that the genus exhibits the structural peculiarities of *Inoceramus*, having a prismatic structure, but is distinct from that genus by its ligamental area, which is continuous and not divided into several pits as is the case in *Inoceramus*.

This characteristic seems perfectly sufficient to fix the genus and to identify similar shells if found elsewhere.

The two species from which the above generic characters were deduced came from beds of uncertain age of the island of Timor, and were detected there by Dr. Schneider associated with *Ammonites megaphyllus*, Beyr. If the ligamental area of these two species had not been detected, they would undoubtedly have passed as *Inocerami*.

The genus *Inoceramus* has already very frequently been quoted from palæozoic strata, but it is more than doubtful whether any of those species belong to that genus. A part of them has been recognised as belonging to the genus *Ambonychia* or *Mytiliarca* of Hall, others, chiefly the Australian ones, have received a proper generic designation, and have been called *Aphanaia* by de Koninck in 1876.

Aphanaia is a genus which is certainly very nearly related to *Atomodesma*, but it is very difficult to pronounce any opinion as to their identity. As has been stated above, the characters of *Atomodesma* were taken from the shell, whilst in *Aphanaia* only internal casts are known. But even in these it can be seen that the ligamental area was entire, and not divided into several pits. The other characters, which are taken from the muscular impressions on the one hand and from the structure of the shell on the other, are incomparable. In general outline both genera agree perfectly well, and I am very much in doubt whether the little shell I have to describe from India should be better placed in the one or in the other genus. Or might de Koninck's sentence: "sommets antérieurs séparés par une area creuse ayant encore un ligament" possibly indicate a generic distinction between the two groups of forms designated as *Atomodesma* and *Aphanaia?*

The systematic position of both genera is certainly in the order *Mytilacea* and the family *Mytilidæ*.

The geological position of the originally described species of *Atomodesma* is not quite certain, as stated above; yet it is possible to say that they must be either of the oldest triassic or of the geologically youngest palæozoic age. The genus *Aphanaia* belongs to the so-called carboniferous deposits of Australia, the exact geological horizon of which seems also not yet quite fixed.

In India a single species of *Atomodesma* has been detected up to the present.

1. Atomodesma indicum, Waagen, n. sp. Pl. XX, fig. 4.

The shell constituting this species is of very moderate size. Its general outline is elongately oval, not oblique, and tolerably inflated, with strong concentric plications.

The beak is very pointed and about median in its position. It is only little bent over. The ligamental area is short, and placed about horizontally, below and posterior to the apex. It bears a very narrow longitudinal groove for the insertion of the ligament, and joins the dorsal margin of the shell in forming an obtuse angle producing a very small posterior wing. From there the posterior margin descends in a low oblique arch.

The anterior margin is obliquely cut off in a straight line from the beak downwards. This oblique truncation is caused by an obtusely rounded ridge, which descends from the beak and encircles a narrow, not very deep, lunula, and is itself again separated from the remainder of the shell by a low but distinct sulca-

tion, which takes its origin at the beak and extends to the ventral margin of the shell.

The ventral margin unites with the anterior one in an obtuse angle, is then slightly sinuated at the sulcation above mentioned, and joins the posterior one in a tolerably broad arch.

The surface of the shell is covered by broad, low concentric undulations, which are somewhat deflected from their course at the anterior sulcation.

The shell, though very thin, exhibits clearly the prismatic structure characteristic for the genus *Inoceramus*.

The measurements of the only specimen are as follows:—

Entire length of the shell	22 mm.
Greatest breadth „ „	14·5 „
Thickness of the left valve	5 „
Apical angle	83°

The greatest transverse diameter (thickness) of the shell is situated about in the middle of its length.

Locality and geological position.—The only specimen of this species in the Salt-range collection was found by myself at Jabi in the same bed in which also *Cyclolobus oldhami* and the other *Ammonitidæ* were detected by me.

Remarks.—The generic position of this shell, as I have placed it, is I think pretty sure and cannot be much doubted. That its general appearance is *Inoceramus*-like, is evident on a first glance, and it is supported by the structure of the shell and the other characters.

From the species of *Atomodesma* hitherto described the Indian shell deviates, however, rather considerably. Two species are mentioned by Beyrich—*At. mytiloides* and *At. exaratum*. Both are much more oblique than the Indian species; if this were not the case, *At. exaratum* would be rather similar. It presents an anterior sulcation, which is, however, much deeper than in *At. indicum;* it deviates otherwise by its much more considerable size and apparently thicker shell, and by its concentric undulations being much less numerous and more distant from each other.

The two species of *Aphanaia* known up to the present are both far more considerable in size, and differ also otherwise so far from the present species that it does not seem necessary to make a closer comparison.

It is worthy of notice that the Indian shell occurs together with all those *Cephalopoda*, which are described on pp. 24 and 34—43 of this volume; and this is a very similar association to that in which the genus was originally detected in the island of Timor, as there also *Am. megaphyllus*, Beyrich, seems to occur together with the *Atomodesma*. The formation in which both of these occur is a complex group of variegated marls and sandstones, the geological relations of which are, however, up to the present very obscure. It is quite unknown in what relation these beds stand to the greenish calcareous sandstones in which carboniferous species of Brachiopods occur.

On the whole, the occurrence of a species of *Atomodesma* in the palæozoic deposits of the Salt-range must always be considered as of high interest.

Family: *AVICULIDÆ.*

Sub-family: *AVICULINÆ.*

Genus: PSEUDOMONOTIS, Beyrich.

This genus, though very characteristic in its typical species, is yet rather difficult to recognise in less typically developed forms. The chief difficulties in this respect arise from the blending together of several genera, the distinct limits of which it is barely possible to trace.

The genus *Pseudomonotis* is chiefly characterised by the strong inequality of the two valves, by the small byssal sinus in the smaller one, and very nearly obsolete wings. But these characters do not always hold good. There are forms which are nearly equivalve, others in which the wings are strongly developed, and so on; and in such cases it is very difficult to decide whether a species should be rather considered as an *Aviculopecten*, an *Oxytoma*, or *Pterinea*. I have accepted as a rule to consider those shells as belonging to the genus *Pseudomonotis*, in which the left valve is more or less strongly inflated and its beak incurved, whilst the right one is considerably flattened, and bears anteriorly a distinct byssal sinus, and in which the sculpture is more or less irregular, the radiating lines of sculpture being often wavering in their direction, suddenly stopping and replaced by others. Smaller species show this latter character less distinctly developed than larger ones.

According to this definition of the genus a number of species belonging to it occur in the palæozoic deposits of the Salt-range. Among them the forms of the highest interest are those which are more or less nearly allied to *Pseudomonotis speluncaria*, Schloth. This latter species is one of the most puzzling that exists in palæontology; and though I have studied a very great number of specimens of it from the German Zechstein, I have not come to a satisfactory conclusion as to its specific characters. There is no doubt that all the different forms which have been described as *Avic. speluncaria*, *radialis*, *garforthensis*, *kazanensis*, *hawni*, *Ostrea matercula*, and many others, are very nearly related to each other, and that in most cases intermediate forms exist which make a distinction very difficult indeed, but nevertheless I should not like to advocate that all those names should be abandoned, and only the one name of *Ps. speluncaria* be retained. It would, for instance, give quite an inadequate idea of the forms of shell occurring in India, if I were to quote simply the name *Ps. speluncaria*, as just that typical form to which the name was originally applied in Europe is altogether absent in India. A name given to a shell is simply the means of conveying to other fellow-workers a concrete idea of what is meant, and this purpose is not gained if we unite too many and different forms under one name. Now-a-days we have in

science in reality only to deal with names, because nobody can say what a species is, or what definition of a species must be given. The time will come when we shall be able to indicate with all possible certainty the rank a certain being should occupy in the succession of affiliated forms, but in the present moment this is only possible in exceptional cases. But if we are ever to arrive at a thorough understanding of the relations which exist between the different forms of life, we must fix the stages by which one form seems to pass into another, or under which a form appears in different geographical and geological positions. Such stages are only fixed, and can be again recognised by our fellow-workers, if proper names be given to them. At the same time we must not forget the relations themselves, and must group the names in such a manner as to bring out such relations as clearly as possible when they are known to exist.

Thus, then, within the group of *Pseudomonotis speluncaria* I shall retain several of the names given by former writers, and which seemed to them necessary to fix certain forms that appeared sufficiently distinct to deserve a proper designation. If such forms can be recognised with all possible certainty among Indian materials, this fact alone goes far to demonstrate the constant recurrence of such forms and their comparatively well-founded specific validity.

Of the varieties, or whatever one may like to call them, of *Pseudomonotis speluncaria*, the following have been collected in the palæozoic deposits of the Salt-range :—

Pseudomonotis garforthensis, King.
„ *radialis*, Phill.
„ *kazanensis*, Vern.

These three species form one group, that of *Pseudomonotis speluncaria.*

Other species of *Pseudomonotis*, which occur in the palæozoic deposits of the Salt-range, cannot be brought directly into connection with *Ps. speluncaria*, though they also seem more or less allied to it ; they are

Pseudomonotis gigantea, Waagen.
„ *inversa*, „
„ *deplanata*, „

The great development of the genus *Pseudomonotis* in the palæozoic deposits of the Salt-range is a remarkable fact of great geological importance. The genus has, up to the present, been taken very little notice of, and thus it is but very rarely quoted from older than permian deposits. Miller in his catalogue puts only *Avicula curta* of Hall from the coal-measures into the genus *Pseudomonotis ;* whilst Stoliczka thinks that already *Pterinea bifida* of Sandberger should be considered as a *Pseudomonotis*. There is no doubt that the number of species, chiefly in the carboniferous formation, will be greater than is at present to be found in the literature; nevertheless this will barely change the fact that the genus is of chiefly permian distribution. In the trias species of *Pseudomonotis* are not very rare in

the Alpine facies of the Bunt Sandstein, but from that upward the genus seems rapidly to disappear.

From the six species found in the Salt-range, three are identical with permian species in Germany, England, and Russia, and three others are more or less allied to such permian species.

Thus the manner in which the genus *Pseudomonotis* appears in the palæozoic deposits of the Salt-range is very suggestive of the idea that the beds in which they have been found are of permian age. This view is supported by the great number of new species furnished by the Salt-range strata. In general the fauna of the mountain-limestone is very uniform over the whole world, and thus the great number of species occurring in the Salt-range, which have not been detected in any other part of the world, is very suggestive of an age differing from that of the mountain-limestone for the strata where these have come from.

This question can, however, only be solved later on in this work, when yet more of the fossils will have been described.

a. Group of *PSEUDOMONOTIS SPELUNCARIA*, Schloth.

1. Pseudomonotis garforthensis, King, sp. Pl. XXII., fig. 2.

1850. *Monotis garforthensis*, King: Permian Fossils, p. 157, Pl. XIII., fig. 24 (? 25).
1861. *Avicula speluncaria*, (Schl.) Geinitz: Dyas, p. 74 (pars).
1866. *Avicula speluncaria*, (Schl.) Geinitz: Carbon and Dyas in Nebraska, p. 28 (pars).

The general form of this shell is roundish oval, very little oblique, flattened, with a small anterior and an about equally-sized posterior wing. From the apex to the periphery along the posterior end of the shell there extends a shallow impression or sulcation, which is, however, so low that it can be seen only with difficulty. This is the general outline of the left valve. The right valve has not been observed.

The left valve shows a slightly prominent, moderately incurved, pointed apex. Below it a tolerably straight hinge line is situated which extends along the two wings. On the anterior side the anterior margin of the shell joins the hinge line at about a right angle, bears a sinuation where the anterior wing joins the body of the shell, and then encircles in an elegant curve the anterior part of the shell. The posterior wing is partly rounded off, and there is no proper limit between the hinge line and the posterior margin of the shell. Also there is a sinuation where the wing terminates below. From there the shell is rather projecting, this being caused by a slight distortion of its whole outline, making the whole shell appear somewhat oblique, the posterior part being more projecting than the anterior. The margin of the shell makes here a convex arch, but is sinuated again further on where the excavation stretching down from the apex reaches the margin. Thus a more or less distinct posterior lobe of the shell is marked off. The posterior margin is not all in one plane, but wavers variously to and fro.

The inferior or ventral margin is simply rounded.

The sculpture of the shell is very irregular and complicated. It consists of two systems, one radial and one concentric. The radial sculpture is composed of radial ridges of very unequal strength. All the ridges are interrupted at certain places by projecting elevated hollow scales. There are about a dozen ridges of the stronger sort, between each pair of which two or three thinner ones are situated. All these ridges are crossed at certain intervals by strong scaly lines of growth, which are, however, not quite regular, but undulating and often disappearing, or one replaced by two others.

The shell is compact, but not very thick.

The dimensions of the figured specimen are as follows:—

Entire length of the shell	60 mm.
Greatest height „ „	83 „
Thickness of left valve	25 „
Apical angle without the wings	115°

Locality and geological position.—There are several specimens of this species preserved in the Salt-range collection, all from Dr. Verchere's collection, and which were all found in the Trans-Indus continuation of the Salt-range. A piece of reddish calcareous shale from Bilot contains several specimens of this species, all closely pressed together. According to the appearance of this rock it must have come from the upper region of the middle division of the Productus-limestone. Another specimen, also from Dr. Verchere's collection, is preserved in a whitish, hard, compact limestone, which also contains remains of *Producti*. It was found in the Rotta Roh, and comes evidently also from the middle division of the Productus-limestone.

Remarks.—All the specimens of this species preserved in the Salt-range collection show dimensions somewhat more considerable than those of the original specimen of *Pseudomon. garforthensis*. But as the only point of difference consists in these more considerable dimensions, I thought this and the slightly deviating sculpture not sufficient whereupon to found a new species. The sculpture of *Pseudomon. garforthensis* consists of numerous radiating ridges about equal in size, between which only sometimes a smaller one is intercalated. The hollow projecting scales are more numerous than in the Indian shell, but if one considers how variable in general is the sculpture of the species belonging to the genus *Pseudomonotis*, these little differences between the sculpture of the one and the other shell can barely be considered as criteria for the distinction of separate species.

The species is very nearly related to the typical form of *Pseudomonotis speluncaria*, Schl. It is, however, as I think, sufficiently well distinguishable from it by its depressed form, its little obliquity, and its little incurved apex.

2. Pseudomonotis radialis, Phillips, sp. Pl. XXIII, fig. 5.

1834. *Pecten radialis*, Phillips, Encycl. Method., Vol. IV, Pl. III, fig. 5.
1850. *Monotis radialis*, (Phill.) King: Monog. Perm. Foss., p. 157, Pl. XIII, figs. 22, 23.
1861. *Monotis speluncaria*, (Schl.) Geinitz: Dyas, p. 74 (pars).
1866. *Monotis speluncaria*, (Schl.) Geinitz: Carbon and Dyas in Nebraska, p. 28 (pars).

This species is represented in the Salt-range collection only by a very small specimen, about half as large as that figured by King, but it is quite sufficient to fix the species.

This specimen is roundish oval in shape, nearly symmetrical, flattened, with two very distinct wings.

The apex is very small, pointed, not incurved; the hinge line rather long and straight. The anterior wing is tolerably large and bluntly angular in its outline; the anterior margin of the shell joining the hinge line in an obtuse roundish angle. This same margin shows a distinct sinuation where the anterior ear joins the body of the shell, and then turns in a slightly projecting arch to the ventral part of the shell.

The posterior wing is sharply pointed, a little smaller than the anterior one; the posterior margin of the shell joins the hinge line in a concave contour; from the base of the wing the outline is somewhat more projecting than anteriorly, from which circumstance the whole outline of the shell becomes slightly oblique.

The sculpture of the shell is very characteristic. It consists of rather numerous radiating ridges of unequal strength. Between two stronger and more elevated ones there is a lower and thinner one intercalated. All these ridges are crossed by rather numerous strong scaly striæ of growth, which at certain intervals cause the radiating ridges in crossing them to appear somewhat swollen or slightly tuberculated. The two wings are very different in their sculpture, the anterior one is radiately ribbed, and its sculpture is in every respect similar to that of the body of the shell, the posterior one, however, is deprived of radial sculpture, and shows only closely arranged striæ of growth.

The dimensions of the little shell are the following:—

Entire length of the shell, about	7 mm.
„ height „ „	10 „
Thickness of the left valve	2 „
Apical angle	165°

Locality and geological position.—The single specimen of this species which has served for the description was collected by myself in the light yellow coloured sandstones which form the top of the upper division of the Productus-limestone at Chidru.

Remarks.—The position of this little specimen in Phillips' species is not above every doubt, as the specimen is so small that the specific characters are not quite well developed in it. But yet I thought it not unjustifiable to assign it

thereto. There can only be the question whether it is a very young specimen of *Pseudomonotis speluncaria*, or whether it might be better placed with *Pseudomonotis radialis*.

In looking through the beautiful and very extensive collections at the Museum of Dresden, I saw a number of such-like young specimens from the German Zechstein, which all agreed perfectly with my Indian shell. There were, however, some in which the anterior wing was radiately ribbed as in my shell; in others this sculpture on the anterior wing was absent. As, then, in *Pseudomonotis radialis* the anterior wing is very distinctly radiately ribbed in typical specimens, I thought that young shells showing this character should be best counted with Phillips' species. All other characters of this little shell are also in accordance with King's figure of *Pseudomonotis radialis*, and thus I think I can safely apply that name to the Indian shell. The posterior wing of the enlarged figure on Pl. XXIII (fig. 5*c*) is too much pointed, owing to an error of the draftsman.

I consider *Pseudomonotis radialis* distinguishable from *Pseudomonotis speluncaria* by its less oblique and more regular shape, the more regular sculpture, and its well developed and nearly equal wings, one of which is radiately ribbed.

This species has a very near ally in North America. This is *Aviculopecten parvulus*, Hall, from the permo-carboniferous formation. The American shell is even smaller than the Indian one, but in general shape they are very similar. The former is only a little more oblique and deprived of the very distinct lines of growth, which are so very conspicuous in the sculptural system of *Pseudomonotis radialis*.

3. Pseudomonotis kazanensis, Vern., Pl. XXII, fig. 3.

1845. *Avicula kazanensis*, Verneuil: in Murchison, Verneuil, and Keyserling, Geol. of Russ., Vol. II, p. 320, Pl. XX, fig. 14.
1850. *Monotis speluncaria*, (Schl.) King: Perm. Foss., p. 156 (pars).
1861. *Avicula kazanensis*, (Vern.) Geinitz: Dyas, p. 75.
1869. *Avicula speluncaria*, var. *kazanensis*, Golovkinsky: On the Permian Formation of the Kama-Volga Basin: Materials for the geology of Russia, Vol. I, p. 376, Pl. IV, f. 19, 21, 23, 24 (non fig. 20).

This is a very characteristic form, which can without much difficulty be distinguished from the typical *Pseud. speluncaria*.

The general form of the shell is elongately oval, not much inflated, with a large anterior and a small posterior wing. The posterior part of the ventral margin is obliquely truncated.

The apex is not very prominent, tolerably pointed, and not very much incurved. The hinge line is straight and not very long, about two-thirds of the entire breadth of the shell. The anterior wing is prominent and obtusely angulated. There is a sinuation at the base of it. Further down the anterior margin is strongly projecting, and then bending round in a flat curve to the ventral margin.

The posterior wing is very small, not quite in a line with the anterior one, and

obliquely truncated at the upper side. The posterior margin joins the hinge line under an angle of 150°, and descends in a nearly straight line to the rather strongly projecting posterior end of the shell, which is narrowly rounded, and then turns in a very flat curve towards the ventral portion of the shell. This latter part is rather narrowly rounded off. Thus the whole outline of the shell assumes more a rhomboidal than an, strictly speaking, oval form.

The sculpture of the shell is very characteristic. It consists of eight or ten thick radiating ridges, between which lie a number (2-6) of very fine undulating ribs. The prominent radiating ribs are nodose at intervals, each of them bearing eight or ten knobs. These ribs are restricted to the body of the shell; both wings are perfectly free of them. Besides this radiating part of the sculpture there are a great many very fine striæ of growth, which cover the whole shell, and are more or less undulating where they cross over the radiating ribs.

The hinge is very simple. It shows in the middle a somewhat triangular emargination, very likely for the reception of a cartilage. Anteriorly to it there is a broad facet, which reaches to the end of the anterior wing. Its lower margin is somewhat prominent and forms a kind of very indistinct elongated tooth. Posteriorly to the ligamental groove the hinge line is simply thickened.

The measurements of the figured specimen are as follows:—

Entire length of the shell	42 mm.
Greatest breadth „ „	40 „
Thickness of the left valve	13 „
Apical angle without the wings, about	80°
„ „ with the wings	125°

Locality and geological position.—The only specimen of this species that has been found in the Salt-range was collected by Mr. Wynne in the upper division of the Productus-limestone at Khund Ghât. It is a left valve only.

Remarks.—There cannot be the slightest doubt as to the identity of the Indian shell with the true *Pseudomonotis kazanensis*, Vern. One needs only compare the figures given in Golovkinsky's memoir with the one on Pl. XXII of this volume, and the identity will be clear at a glance.

Another question is whether the name *kazanensis* can be rightly applied to the form here under consideration. The figures given by de Verneuil in the geology of Russia are very insufficient and not likely to lead to the conclusion that the full grown form would look like the shell I have figured. In the description of the species de Verneuil, however, remarks that his *Avicula kazanensis* was a very common shell in the country around Kazan and chiefly at Ustlon. This very common species has now been collected in great numbers by Golovkinsky, and after having studied the species carefully he came to the conclusion that fig. 14*a* of Verneuil is very bad, and that the species is never so oblique as it is represented there. The full grown form has been figured by him, and his figure agrees, as stated above, exactly with the Indian shell.

Pseudomonotis kazanensis is distinguishable from *Ps. speluncaria* by the great development of its anterior ear, the very great inequality of its radiating ribs and by the constant absence of the posterior sulcation, which in *Ps. speluncaria* is so very conspicuous, and which also exists, in a much less degree, in *Ps. garforthensis*. All these characters seem to distinguish the form quite well from Schlotheim's species, and they seem perfectly sufficient for the establishment of a proper species.

Pseudomonotis hawni, M. & H., of the permian beds of North America seems to be very nearly related to the present species.

b. ISOLATED SPECIES.

4. PSEUDOMONOTIS GIGANTEA, Waagen, n. sp. Pls. XXI., XXII., fig. 1.

Of this very large species a fragmentary specimen, in which both valves are present, is preserved in the Salt-range collection.

The general form of the shell seems to have been nearly circular, little oblique, flattened, with not very strongly developed wings.

The left valve is much larger than the right one. Its apex is obtuse, not prominent, not enrolled. The hinge line is not preserved, but seems to have been straight and rather long. It cannot be stated how large and of what shape the wings may have been; so much, however, is certain that the anterior wing was much larger than the posterior one. The anterior margin of the shell is gently rounded; all the other margins are broken off.

The sculpture is very characteristic, although the fossil consists of a cast only. From the apex there descend towards the periphery of the shell four highly prominent rounded ridges, which are indistincty bifid about half way towards the margin of the shell. Between these prominent ridges there is a great number of very fine radiating striæ or ribs, 18—20 and more, between each pair; they are very irregular and often divided towards the periphery of the shell. The striæ of growth are, as must be expected on a cast, very indistinct; they are rather far apart, and more or less irregular. If the shell was perfectly preserved it is probable that the termination of the strong prominent ridges at the periphery would project beyond the margin in long thorn-like processes.

The shell is not much inflated, but rather flattened. Its greatest thickness is not far from the apex.

The right valve is very different from the left one, and being much smaller, a greater portion of it is preserved on the piece of rock containing the fossil, and a more accurate description of its shape can be given. It is like the other valve about circular in its outline, slightly oblique, with a deep byssal sinus on its anterior part, and apparently a large anterior and a small posterior wing.

The apex is not at all prominent, not enrolled, and like the whole valve nearly quite flat. In the vicinity of the apex the shell is still preserved as a rude mass of

calcspar. It seems to have been tolerably thick. Towards the periphery some layers of shelly matter are left, but not in its entire thickness.

The sculpture of this valve is very different from that described on the other valve; it consists of straight radiating ribs, not very strong in comparison to the size of the shell, and though they are not all of equal strength, none are very prominent, as is the case in the other valve, but all are, notwithstanding minor differences, of about equal development. The striæ of growth are few in number and at very unequal distances.

The measurements of the specimen are as follows:—

Entire length of the left valve, about	159 mm.
„ height „ „ „ probably	163 „
Thickness of the left valve	34 „
Entire length of the right valve, about	131 „
„ height „ „ „	140 „
Thickness of the right valve	11 „
„ of both valves	51 „
Apical angle without the wings	130° to 140°

Locality and geological position.—The only specimen of this species comes from Dr. Verchere's collection. It is preserved in a very hard, ringing, compact limestone of somewhat greenish-grey colour. It was found by Dr. Verchere in the Rotta Roh, but the exact locality is not known, nor the bed from which it came. From the character of the rock in which the fossil is preserved it is probable that it came from the middle region of the Productus-limestone.

Remarks.—This fossil cannot be compared to any of the hitherto described species of *Pseudomonotis*. By the character of its sculpture it recalls to a certain extent the form of *Ps. speluncaria*, or more particularly that of *Ps. kazanensis*, and it thus may stand in a certain relation to the group of these shells; nevertheless I should not like to directly put it into the group of *Ps. speluncaria*.

5. Pseudomonotis inversa, Waagen, n. sp. Pl. XXII, fig. 4.

This little shell is remarkable on account of its general outline, which is elongately oval, with a very large posterior ear, and a nearly quite obsolete anterior.

The apex is tolerably prominent, little incurved. The hinge line is short and straight; anteriorly it terminates very close in front of the beak, forming a very small anterior ear, which is entirely concealed in a kind of deep lunula excavated in the anterior side of the valve. The anterior margin of the shell forms an obtuse angle with the central margin where the lunula terminates.

Posteriorly the hinge line extends over the large posterior ear, which is cut off by the posterior margin of the shell in an obtuse angle. There is no sinuation of the margin where the wing unites with the body of the shell, and the posterior margin joins the ventral one in a well-rounded curve.

The sculpture of the shell consists in numerous fine radiating ribs, which are alternately stronger; but this difference in strength is not much. These radiating ribs are crossed by numerous very fine striæ of growth, without giving a scaly appearance either to the ribs or to the spaces between them.

The substance of the shell is thick and heavy. The valve is rather strongly vaulted. This is only the left valve. The right valve has not been observed.

The dimensions of the figured specimen are as follows :—

Entire length of the shell	15 mm.
„ breadth „ „	14 „
Thickness of the left valve	5 „
Apical angle	125°

Locality and geological position.—The only specimen of this species in the Salt-range collection was found by myself in a grey sandstone forming the top bed of the upper division of the Productus-limestone at Amb.

Remarks.—This species resembles somewhat *Pseud. radialis* Phill., but the absence of an anterior ear, the much finer striation, and the thick heavy shell make a distinction not difficult; of other species there is none to which it could be compared.

6. Pseudomonotis deplanata, Waagen, n. sp. Pl. XX, figs. 16, 17.

This is a species the generic affinities of which are very difficult to determine. There is no complete specimen in the Salt-range collection, and thus it is not easy to give an exact description of the species. Nevertheless the shell is of interest, and I thought it not advisable to leave it unnoticed.

I think the specimen is a right valve, but this cannot be decided definitively, as the wings are not visible.

The general outline of the shell seems to have been nearly circular or broadly triangular, but this either cannot be well determined. Similarly it cannot be seen whether there were ears, and of what shape they were. The shell is rather flattened and depressed, and might as well be a *Hinnites* as a *Pseudomonotis*.

The only thing that can be well seen is the sculpture. This consists of about ten rather strong prominent ribs, which radiate in a diverging manner from the apex. On these ribs at certain irregular intervals prominent hollow shelly scales are placed. Between the principal ribs a number of smaller or thinner ones occur, generally six or seven in the space between two larger ones. All these ribs are slightly undulating and wavering in their direction. A small fragment, which I consider to belong to the same species, and which I have figured, Pl. XX, fig. 17, exhibits this irregular sculpture most clearly.

Between the ribs very numerous fine striæ of growth are visible.

The measurements cannot be taken on any of the specimens, as they are too imperfectly preserved.

Locality and geological position.—There are two specimens of this species in the Salt-range collection, both found by myself. The more complete of them is preserved in a grey, shaly, calcareous rock, very argillaceous and slightly oolitic; the other smaller fragment is contained in much the same rock, which has, however, by the action of weathering, become of a dark-yellow colour. Both specimens come from Chidru, where they were found in the middle region of the upper division of the Productus-limestone in the identical bed with *Xenodiscus carbonarius*, W.

Remarks.—It will seem, I fear, rather hazardous on my part to found a new species on such indifferently preserved specimens as those by which the present species is represented, but by these specimens the existence of a further species, very likely belonging to the genus *Pseudomonotis*, is proved beyond any doubt, and the drawings I have given will be, I think, sufficient to recognise the form if found again in the Salt-range or elsewhere, and thus I think it will be by far more convenient to give a name to this shell than to carry it on in the literature as *sp.*, without a name.

In its general form and kind of sculpture this shell recalls several species described by former authors. There is the *Pecten kokscharofi*, Vern., which is slightly similar, also *Pect. bouei*, Vern., but in both the similarity is only a distant one. A much closer resemblance exists between the present species and a shell fragment that has been figured by Meek in the final report on Nebraska as *Pseudomonotis*, sp. This fragment is only distinguishable by its somewhat finer ribs, but otherwise it might belong to the same species. As it is, however, only a fragment, nothing certain can be said about it. Of other species, only *Pect. subclathratus*, Keys, might be mentioned, but the figure of it is so bad that an exact comparison between this species and the Indian shell seems barely possible.

Genus OXYTOMA, Meek.

The genus *Oxytoma* differs very little from *Pseudomonotis*, and when the wings of the specimens are not well preserved, it is very difficult to state with which genus a shell should be counted. Thus Stoliczka seems to be right when he advocates that the two genera should be united. There are indeed some jurassic species, like *Avic. echinata, tegulata*, etc., in which a distinction from *Pseudomonotis* is very difficult; but other species again like *Avic. münsteri, inæquivalvis*, etc., bear such a characteristic kind of sculpture, not to speak of the different development of the wings, that it is not impracticable to follow Meek's example, and to consider these forms as constituting a separate group which deserves a proper designation.

A species which according to its sculpture must be counted with the genus *Oxytoma* occurs in the palæozoic deposits of the Salt-range, and is of great interest

for the sole reason that in its general form and sculpture it recalls much more recent species of the genus. Thus it may be safely considered as the geologically oldest representative of the genus, known up to the present.

1. Oxytoma atavum, Waagen, n. sp. Pl. XX, figs. 6, 7.

Several specimens of the left valve of this species are known to me, but of the right valve not a single specimen has been detected up to the present.

The general outline of the left valve is roundish oval, slightly oblique, and strongly inflated. The wings are not perfectly preserved in any of the specimens, but seem to have been very small.

The apex is small, little prominent, obtuse, and strongly bent over. The hinge line seems to be tolerably straight, extending over both wings. The anterior ear is very small, little prominent, and obtusely angular. The rounded anterior part of the shell projects far in front of the wing.

The prosterior wing is larger than the anterior one, and seems to be also obtusely angulate. It reaches further down the posterior margin, but nevertheless this margin also projects far beyond the posterior termination of the wing; it is flatly rounded, and joins the ventral margin without forming any angle.

The outline of the whole periphery of the shell, except the hinge line, is very characteristic, and is caused by the kind of sculpture which covers the surface of the shell. It is provided with ten long thorny processes which project a long way from the margin of the shell.

The surface sculpture consists of ten strong, radiating costæ, which are sharp and cutting at top, and broad at the base with sloping sides, thus exhibiting a roof-like appearance; they are limited on both sides by deep furrows. The spaces between them are slightly arched, and some three or four very fine radiating ribs are visible on them. The whole shell is covered by numerous fine concentric striæ of growth, which are chiefly visible in the spaces between the high ribs. They are not straight, but undulating and deflected from their course by the fine ridges intercalated between the high ones.

The high costæ project, as indicated above, a long way out from the margin, making it appear deeply indented.

The substance of the shell is not very solid. The left valves are strongly inflated or vaulted.

The species seems to have attained a rather considerable size, as the fragment figured on Pl. XX would indicate a shell of at least 45 to 50 mm. in diameter. The measurements of a smaller specimen are as follows:—

Entire length of the shell	29 mm.
„ breadth „	23 „
Thickness of the left valve	8 „
Apical angle	120°

Locality and geological position.—There are three specimens of this species preserved in the Salt-range collection which were all found by myself. All three are left valves. The largest specimen, which is, however, only fragmentary, was procured at Jabi in the upper division of the Productus-limestone, in the same bed in which *Cyclolobus oldhami* occurred. The other two specimens were detected by me in the upper region of the middle division of the Productus-limestone, one at Khura in a grey shaly limestone, and the other in the Chíta-wán, in a brownish coloured limestone.

Remarks.—The general outline of this shell has remained a great riddle to me, and even now I am not perfectly certain how to interpret what can be observed. If we compare different specimens of this species, we find that they are turned different ways, and it appears as if we had to deal with right and with left valves. If this were the case, the shell would have been equivalve, and could not belong to the *Aviculidæ*. The structure of the shell, however, as well as the kind of sculpture, agree so very well with the *Aviculidæ*, that I do not think it will be possible to assign this shell to any other family. The proper way to consider these irregularities is, I think, to suppose that the typical form of this shell is about equilateral, with median beaks. In certain varieties the anterior part of the shell may be more prominent, in others the posterior one, and thus the shell appears sometimes turned to the right, sometimes to the left side, though only left valves may be accessible to observation. In this respect the shell here under consideration resembles greatly the nearly equilateral species of *Pseudomonotis*.

This shell is of rather extraordinary shape for a palæozoic species, and we must go rather far up in the series of formations before we encounter similar forms. In the permian strata there is no shell which could be closely compared with the present species, nor is there in the Bunt Sandstein or Muschelkalk formations anything similar. In the upper trias (Kössen beds) species of *Oxytoma* begin to make their appearance in Europe, and from that upwards throughout the jurassic and cretaceous formations numbers of species occur. Of jurassic species chiefly the forms belonging to the group of *Avicula interlævigata*, Phill., from the Yorkshire lias, and those more or less allied to *Oxytoma costatum*, Sow. sp., from bathonian strata, recall to a certain extent our species; but the posterior wing in those forms is much larger, and the strong costæ are not so prominent, and not sharp at the top with sloping sides. If, however, *Oxytoma atavum* is somewhat worn down by weathering, it resembles greatly the bathonian shell, or not less *Oxytoma inæquivalvis* or *münsteri* from liassic and inferior-oolitic strata, the only striking difference consisting in the more equilateral form.

The occurrence of such a form in the strata of the Salt-range gives a very recent habitus to its bivalve fauna. The mixed character of this fauna, which I have already several times had occasion to allude to, is particularly well illustrated by such a species.

Genus AVICULA, Klein.

This is a very well known genus, but there is much discrepancy of opinion as to how it should be named. In the more recently published works on conchology or palæontology we find in one the name *Avicula*, whilst in another the same shells are subsumed under the name of *Pteria*. In England and Germany the name *Avicula* has long been used in preference, but in America the name *Pteria* has been adopted in recent publications. The reasons for this proceeding are given by Meek in his "Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri." He says that the name of *Avicula* was not used by Klein in a strictly binominal sense, and that before Klein's name had come into proper use, Scopoli proposed for the same shells the name of *Pteria*, which ought, therefore, to be used in preference. Nevertheless the name *Avicula* has come into general use, and every man of science immediately knows in hearing the name what is meant by it. Though it may be more in accordance with the rules to reject the names published previously to 1758, yet it seems only natural that general usage should have some weight in the retention or rejection of names. To reject a name which has been perfectly well founded, the characters of the genus having been well recognised and typical species having been quoted, simply on the ground that it was published five years previous to the normal year of 1758, notwithstanding that it has been adopted generally in science, is, I think, going too far. It is something different with names that have escaped general notice, and which thus have not come into general use. In this case I should not think it prudent to rescue such names from their general oblivion, and to re-establish them in spite of another name having a due claim as published after the year of 1758, and which had come into general use.

Thus, I think it better to retain the name *Avicula*, Klein, in preference to *Pteria*, Scopoli, which, though published in 1777, has never come into general use, and is a stranger, or at least not a current name, among most men of science.

The genus *Avicula* is already largely represented in palæozoic formations, though many of the species quoted as *Avicula* will have to be considered as belonging to other genera. From the carboniferous formations a great many species are known, but in the permian the genus seems to be again very much reduced in numbers. In the trias the number of species increases again, and is largest in jurassic and cretaceous times, though true *Aviculæ* seem to have been never very numerous.

In the palæozoic deposits of the Salt-range a very interesting little species of *Avicula* occurs. It is on the one hand very nearly related to *Avicula sulcata*, Gein., of the permo-carboniferous strata of Nebraska; on the other hand, in its general outline it has a somewhat surprising similarity to *Avicula socialis* of the

Muschelkalk. This latter similarity is, however, only an apparent one, as *Avicula socialis* is not an *Avicula*, but a *Gervillia* with distinct ligamental grooves in its hinge area.

There is, however, a little *Avicula* in the Muschelkalk formation, *Avicula bronni*, which bears a rather close resemblance to the Indian fossil.

1. Avicula chidruensis, Waagen, n. sp. Pl. XX, figs. 8-10.

This is a rather variable shell; it can, however, in all variations of its external shape be always readily recognised by the high sharp concentric lamellæ which cover the surface of the left valve, and by the deep sulcation which runs from the apex over the anterior face of the shell to the ventral margin.

In general the outline of the shell is transversely oval, very oblique, with a tolerably large posterior wing, and a very small anterior.

The left valve is rather strongly inflated; the beak tolerably prominent, acute, and strongly incurved. Below the beak there is a distinct smooth area, which extends along both wings, and forms a straight hinge line. The beak is nearly terminal, the anterior wing being so small as to be barely prominent. This wing is very obtuse, and in some specimens (forming a somewhat shorter variety) there is a short anterior margin of the shell distinguishable; in other specimens the margin of the shell descends immediately from the obtuse termination of the anterior wing in a very oblique curve to the ventral side of the shell. This latter is very flatly curved and slightly sinuated in its anterior part. Posteriorly a rather large wing is present. The shape of this wing is very different in different specimens, as may be seen from the figures on Pl. XX. It is sharply pointed and sinuated at its base in the longer and more oblique varieties, and obtuse, with a sloping posterior margin, in the shorter and less oblique specimens. The posterior part of the shell is in different individuals more or less strongly projecting beyond the base of the wing, and sometimes almost pointed, sometimes more or less broadly rounded. The sculpture of the left valve is most characteristic. Even small fragments of the shell can be easily recognised by the high sharp concentric lamellæ, which at certain intervals cover the whole surface. They follow the margins of the shell in all their curves, but are most distinct and at the same time most distant from each other on the high crest, which extends from the apex to the posterior end of the shell, marking off the posterior wing.

This crest is rounded on its top, producing a concave curve; from this to the anterior side the shell is slightly convex, and similarly to the ventral margin. On the anterior part of the beak a distinct sulcus takes its origin, extending in a radial and somewhat posterior direction to the ventral margin of the shell. It is limited on its posterior side by a sharp angular crest, on its anterior side by a rounded elevation. It becomes rapidly broader as it approaches the ventral margin.

The right valve is considerably smaller than the left one, and rather flat. The beak is very small, little prominent, and barely incurved. From the apex to the posterior end of the shell there runs a low elevation marking off the posterior wing. The anterior ear is barely distinguishable. Corresponding to the sulcation of the left valve, there extends a very flat impression anteriorly from the apex to the ventral margin of the shell. The concentric sculpture so characteristic on the left valve is absent on the right one; but in this valve the whole surface is covered by very closely arranged lamellar striæ of growth.

The hinge cannot be observed in any of the specimens, but enough is seen to show that there are no such ligamental grooves as in *Bakevellia* or *Gervillia*.

The measurements of the two specimens are as follows:—

	I.	II.
Greatest length from the posterior to the anterior end	17 mm.	19 mm.
„ breadth from the lowest part of the ventral margin to the apex	11 „	10 „
„ „ of the right valve	10 „	?
Thickness of the left valve	5 „	5 „
„ of the right valve	3 „	?
Apical angle	110°	110°

Locality and geological position.—This species is not at all rare in the palæozoic deposits of the Salt-range, but it seems to be restricted there to the topmost beds of the upper division of the Productus-limestone. It is, however, not easy to get good specimens out of the very hard rock. All the specimens of the species in the Salt-range collection were found by myself. The greater number (six) are from Chidru, where the species occurs in a hard yellow sandstone, forming the highest bed of the upper division of the Productus-limestone. In the same geological position in a hard grey sandstone two other specimens were collected by me at Amb.

Remarks.—This species is of high interest, as it is again one of those presenting great similarity to a North American form, yet not identical. These shells can only be considered as vicarious species, representing a certain group of forms in geographically distinct geological provinces.

The species to which the present one is most nearly allied is *Avic. sulcata*, Geinitz, of the permo-carboniferous beds of Nebraska. More recently the same species has also been detected by Prof. Golovkinsky in the permian limestones of the country near Kazan. This species can be easily distinguished from *Avic. chidruensis*, W., by the presence of two anterior sulcations, whilst there is only one in the Indian shell. Otherwise the two species are very similar, and seem to replace one another.

As has been stated above, the similarity of the *Av. chidruensis* to *Gerv. socialis*, Schl. sp. and other species of the Muschelkalk is only an apparent one, as the two shells belong to different genera. It has, however, already been remarked by Geinitz that his *Avic. sulcata* had a strong resemblance to some triassic species.

Associated with the *Gervilliæ* in the German triassic strata there is, however, a

species of true *Avicula*, which has been demonstrated to be such by Giebel, from specimens in which he had been able to clean the whole hinge line from the adhering rock, showing that no separate pits for the insertion of a divided ligament were present. His indications were called in doubt by Seebach, who considered the absence of pits as purely accidental and caused by the mode of preservation. On the other hand, Noetling has most recently accepted Giebel's *Avicula bronni*, stating that it most certainly was distinct from the similar species of *Gervillia*. This *Avicula bronni* now seems to be most nearly related to our *Av. chidruensis;* it is best distinguished by its large posterior wing and a deeper sulcation on the anterior part of the shell. The other characters are all identical, and even the sculpture seems to be very similar in certain varieties.

It is a very remarkable fact that *Av. chidruensis*, W., should be so very nearly related to this triassic shell, while it is not quite so similar to permian species, and only in remote affinity with the fossils from the mountain-limestone.

If we look through the German and English permian species, we find that in general outline several can be compared to the fossil here under consideration; as, for instance, *Bakevellia ceratophaga*, Schloth., *Bakev. antiqua*, Münst., etc. But in these shells the condition of the hinge is sufficient to distinguish them from *Avic. chidruensis*, as they possess a divided ligament, which is continuous in the Indian shell.

Of mountain-limestone species, *Avicula recta*, M'Coy, is not dissimilar in its sculpture, but the anterior sulcation is absent, and the whole shell is less inequilateral.

Sub-Family *MELININÆ*.

Genus LIEBEA, Waagen, n. gen. Pl. XXIV, figs. 13-16.

In working up the bivalves of the palæozoic deposits of the Salt-range I found a small shell, which on a first glance seemed to be a *Gervillia* with little developed posterior wing, and which for a long time I considered as such.

When, however, I came to study the fauna of the German Zechstein, in order to find out in what relation this fauna might stand to the palæozoic fauna of the Salt-range, I was struck with the similarity my little *Gervillia* exhibited to certain specimens of *Aucella hausmanni*, and I was very soon convinced that both shells belonged to one and the same genus.

That German species had been described originally as a *Mytilus* by Goldfuss under the name of *Myt. hausmanni*, and was subsequently transferred by Geinitz to the genus *Aucella*. It is evidence of much palæontological skill on the part of Mr. Geinitz to have placed this shell in Keyserling's genus, because decidedly *Aucella* is the only genus into which these shells can be brought, if one does not wish to create a new genus for their reception, and it was rather out of place to blame that author on account of his having called that shell *Aucella hausmanni*.

That these shells belong to the *Aviculidæ* is already very probable from the inequality of their valves and the scaly surface of the shell; but if one wishes to retain more narrowly limited genera, and to introduce into palæontology the sharper distinctions applied most recently in the description of the now living shells, the fossils here under consideration cannot be assigned to *Aucella*, or to any of the established genera of *Aviculidæ;* they seem to form the type of a new genus.

The genus *Aucella* was characterised by Count Keyserling in a truly excellent manner, and from his description it can easily be seen that we have to deal here with a shell very nearly related to Keyserling's genus. A point of similarity, which is very striking, is the peculiar development of the anterior ear in the left valve, as occurs in a more or less similar manner in the different species of *Aucella*. Also the general outlines of *Myt. hausmanni* and of *Aucella* are not dissimilar, and thus Geinitz's views, that this shell should be considered as forming part of the genus *Aucella*, can very well be justified. It is certainly more justifiable than to consider *Myt. hausmanni* as a *Myalina*.

With these points of similarity there exist, however, also discrepancies of a rather grave nature. If we consider the right valve, we find no byssal incision in this valve in *Myt. squamosus* or *hausmanni*, and this character alone would be sufficient to distinguish this shell generically from *Aucella*. Other dissimilarities can be observed in regard to the ligament; it is quite internal in *Myt. hausmanni*, and generally placed in a number of separate pits, which are not well observable in young specimens, but are always present in old ones. Taking all these characters into consideration, we can say with confidence that we have to deal here with a new genus, more or less allied to *Aucella*, but certainly different from it.

This new genus may be characterised in the following manner:—

Shell inequivalve, the right valve smaller than the left one; inequilateral, mytiliform, with a small, not very distinct, posterior wing in both valves, and with a very small anterior wing in the left valve only. The position of this latter wing is not as in other *Aviculidæ*, but is placed about vertically to the plane of the valve, turning round the smaller right valve and embracing it partially. This wing is compressed from both sides, bearing on its top a sharp ridge, which projects at about right angles from below and in front of the beak of the left valve, terminating the area of that valve anteriorly and giving it a squarish shape.

In the right valve the existence of an anterior wing is barely indicated. In its place there is an incision of the shell, into which fits the bent-over anterior wing of the left valve.

Both valves are provided with a more or less distinct sharply defined area, which is linear in young specimens and very broad in old ones. It is smooth, and only covered by distinct striæ of growth, parallel to the hinge margin.

The area in the left valve is broader than that in the right one.

The entire hinge line serves for the attachment of a quite internal ligament.

This ligament seems to be linear in young specimens, but in old ones it is distinctly divided in several parts, which are attached to a number of pits, between which the hinge margins of both valves seem to have nearly touched each other. The number of pits is generally four or five. The first is situated just below the beaks, the others are distributed over the posterior part of the hinge line.

The hinge seems to have been quite edentulous, as no trace of teeth has been detected up to the present.

Internally, below and in front of the beaks, there is in each valve a small septum, which separates the anterior wing from the remainder of the shell.

The muscular and pallial impressions cannot be observed in any of the specimens at my disposal. They have been described accurately by King, only the position of the anterior adductor, as indicated by him, seems to be somewhat doubtful. If the anterior adductor had been attached to the anterior wing of the shell, it must have been much larger in the left than in the right valve, as in the latter this wing is so rudimentary that there was not much place for the attachment of a large muscle.

Of the characters indicated in this diagnosis only the condition of the ligament will possibly be doubted by some, as a crenulation of the hinge line in casts has been observed by Geinitz, but was taken by him to be a result of weathering. I was able, through the kindness of Director Liebe in Gera, to examine a very great number of specimens of *Myt. hausmanni* from different beds of the German Zechstein, and I most decidedly can assert that this crenulation is not produced by weathering, but is an essential character of the hinge line of adult specimens. And not only in the German specimens was I able to mark this character, but also in the Indian fossil. As the shell of these species is never very thick, and the ligament entirely internal, it is only natural that in young specimens this character cannot be well observed, but in adult shells it can always be seen.

If only single valves were accessible to observation, it would be difficult to find out whether the crenulation of the hinge line was caused by a dentition, as in Arca or Crenella, or by the ligament being attached in separate pits. As, however, duplicates are numerously found, it is very easy to decide that the crenulation of the hinge line is caused by pits for the attachment of the ligament. The projecting parts of the hinge line, as well as the grooves, are not alternating, but correspond with each other on both sides.

The characters exhibited by the shells belonging to this genus are of a most conflicting kind, and it seems very difficult to decide in what family these shells ought to be placed. The general form recalls most the family of the *Mytilidæ*, with which also the quite internal ligament is in accordance. On the other hand, it cannot be denied that the shells here under consideration are also very nearly related to *Aucella*, a genus of the *Aviculidæ*. I have placed the genus provisionally in the sub-family *Melininæ* on account of its ligament being divided into several parts attached to different pits of the hinge line. Here it will very likely have to

be placed next to *Bakevellia*, King, from which the present shell can easily be distinguished by the smooth area, absence of hinge teeth, and strange development of the anterior wing.

Inoceramus might also have some relation with the genus under notice, but neither in the German nor in the Indian specimens can the structure of the shell be well observed.

I call this genus *Liebea* in honour of Director Prof. Dr. Liebe in Gera, who has furnished me with ample materials for comparison, and whose name, since the beginning of the more accurate studies of the permian formation of Germany, has been intimately connected with those studies.

The geological distribution of the genus *Liebea* seems up to the present to be very restricted, and so is the number of species. In Europe there seem to occur two: *Liebea squamosa*, Sow. sp. (*hausmanni*, Gdf. sp.), and *Liebea septifer*, King sp., both coming from the permian formation of Central Europe. The third species belonging to the genus has been found by me in India, and will be described under the name of *Liebea indica*, W.

It is doubtful whether the genus occurs in the permian beds of America. *Mytilus hausmanni* is quoted from there, but it remains doubtful whether it is identical with the European shell.

1. Liebea indica, Waagen, n. sp. Pl. XX, fig. 5; Pl. XXIV, fig. 13.

The general outline of this shell is mytiliform, elongately oval, with a moderately developed posterior wing and anterior beaks. The two valves are different in size, the left one being the larger; they are very little inflated.

The beaks are pointed, quite anterior in their position, and barely at all incurved. In the left valve there is a very small anterior wing, which bends nearly vertically round to meet the smaller right valve and envelopes the beak of the latter almost entirely. It commences immediately below and slightly in front of the apex, and bears a high and sharp crest on the top, on the inside of which is the line where the valves meet. In this place there must be a sinuation in the smaller valve, replacing partly the anterior ear, but this sinuation is not very large, and there is always found a trace of an interior ear in the smaller valve also.

Below this anterior wing a distinct sinuation in the outline of both valves takes place. From there the anterior shell margin descends in a nearly straight line, and meets the ventral margin in a rather broad and prominent curve. Also the posterior shell margin ascends in a nearly straight line, being only very flatly arched. It meets the perfectly straight dorsal margin under a very obtuse but distinct angle.

Posteriorly to the beaks there extends a distinct triangular area in both valves, quite smooth, only covered by more or less distinct lamellæ of growth, and limited

on its lower side by the perfectly straight hinge line. The hinge lines of both valves touch each other for their entire length, and nothing of a ligament is visible; only after scratching away a thin shelly layer at certain distances along the hinge line could pits be observed, which served for the attachment of a divided ligament. There seem to be four of these pits present, but a quite certain observation as to their number has not been possible, as the hinge had partly been broken in trying to clean it from the adhering rock.

Of hinge teeth not a trace could be observed.

The substance of the shell is not very thin, and is composed very distinctly of two different layers, one outer layer, which is rather thin and of a brown colour, and a somewhat thicker inner layer, composed of white calcspar. The materials were too scanty to admit of making microscopical preparations to observe the finer structure of these two layers.

The original colour of this shell has apparently been preserved, and seems to have been a uniform dark reddish-brown.

The surfaces of the valves are differently arched. The greatest thickness of each valve is below and a little posteriorly to the beaks. The posterior wing is flattened. The surface sculpture of the shell consists in scaly concentric striæ of growth, which are of very unequal strength, interrupted sometimes by more prominent folds marking larger stages of growth.

The measurements of the only specimen are as follows:—

Entire length of the shell (from anterior to posterior margin)	11 mm.
„ height „ (from apex to ventral margin)	18 „
Greatest thickness of both valves	6 „
Thickness of right valve	4 „
„ left „	2·5 „
Apical angle	52°
Angle of posterior margin with dorsal margin	133°

Locality and geological position.—The only specimen of this species that has been found up to the present was collected by myself near Amb in a black, coaly, argillaceous sandstone, at the very base of the Productus-limestone formation, containing much pyrites and many specimens of Aulosteges, and resting immediately on 10 feet of Lavender-clay, below which a 20 feet thick bed of red and white speckled sandstone follows.

Remarks.—The species here described is most nearly related to *Liebea squamosa*, Sow. sp. (*Myt. hausmanni*, Gdf.), and there will be many who would consider the Indian species as identical with the European one rather than recognise a specific distinction. It cannot be denied that the characters, by which it is possible to distinguish the two shells, are in fact of minor importance, but as an absolute identity cannot be established between the two forms, and as it would be of so much geological consequence to identify specifically this shell with a permian fossil, I thought it more prudent to describe the Indian form under a proper specific desig-

nation. The characters by which the two species can be distinguished are, the less considerable inflation of the valves, and the less rounded outline of the posterior wing in the Indian shell; both characters can be well seen in the figures on Pl. XXIV, where I have had drawn several specimens of *Liebea squamosa* for comparison.

But already the occurrence of the genus *Liebea* in the lowest fossiliferous beds of the Productus-limestone is of very great interest, as the genus recurs, so far as is known up to the present, exclusively in the permian beds of Europe. Though the generic identity of this single shell with an exclusively permian genus is not an overwhelming proof for the permian age of the beds in which it occurs, yet it adds one more to the facts which may serve to settle definitively the question of the age of the Productus-limestone in the Salt-range.

Order: OSTREACEA.

Family: *RADULIDÆ.*

Genus: LIMA, Brug.

The name of this genus seems at present not very strictly settled; it therefore requires some remarks on my part as to why I use the name *Lima* in preference to the name *Radula* of Klein, which is in reality the older one.

Already in the introductory remarks to the genus *Avicula* I have indicated my views in this respect, and I can only repeat here that Klein's names having been published previous to the year of 1758 ought not to be employed if they have passed into oblivion since; and they must not be re-established now in the place of other well known and much employed names. This rule would, of course, not apply when Klein's names had come into general use in the early times of malacogical enquiries. It will never do to rush into extremes in these questions; here, as in so many other matters, the proverb "summum jus summa injuria" finds its application. Names like *Avicula*, *Lima*, *etc.*, have attained a historical right to existence, though the rules if strictly applied would not allow them to stand. If we will not acknowledge such historical rights, our nomenclature can never come to anything like stability. There will ever be some old name or other unearthed to replace a more recent and generally accepted name, and thus changes without end will ensue. The general use and the general familiarity with the denotation of such a name is, I think, of much more worth than the right of priority of some old writer.

The genus *Lima* is very rare in palæozoic formations; and all that have been described under that name from older formations than carboniferous must be transferred to other genera. The geologically oldest species of *Lima* that are known at present with certainty are those described by de Koninck from the carboniferous deposits of Bleiberg. The species assigned to the genus by M'Coy are

all more or less doubtful. In permo-carboniferous beds the little *Lima retifera* occurs in America, whilst in the permian strata of Europe *Lima permiana*, King, represents the genus. With the triassic formation the genus takes a very sudden development, numbers of species of large size making their appearance. From these upwards the genus increased slowly in numbers during jurassic and cretaceous times, but in tertiary and recent formations it is decidedly on its decline.

In the palæozoic deposits of the Salt-range a very nice little species occurs, which in its sculpture and outline shows the typical characters of the genus. In its general appearance it resembles palæozoic more than triassic species.

1. LIMA FOOTEI, Waagen, n. sp. Pl. XX, figs. 14, 15.

This little species is of an elongately oval shape, produced anterior and very short posterior side, small wings, and not much inflated valves.

The apex is somewhat posterior in its position, little prominent, pointed, and not much incurved. On both sides of it small wings are present, the anterior one being the smaller. On their upper side they are cut off by a straight hinge line. The anterior shell margin originates at this hinge line under an obtuse angle, and then descends nearly straight and obliquely to the very prominent and not very broadly rounded anterior part of the shell. The lower or ventral margin of the shell forms a rather flat, not quite symmetrical, arch, which joins without any demarcation the broadly rounded, very little prominent, posterior margin. The hinge line forms with the posterior margin an angle, only slightly larger than a right one.

The general outline of the shell is, however, subject to slight variations in different individuals, such as the posterior part of the shell being sometimes more narrowly rounded and slightly more prominent, and as both wings being sometimes marked off in the outline of the shell by slight sinuations. Also the obliquity of the shell is not always perfectly the same.

The valves are not strongly inflated, and thus the lunula on the anterior part of the shell is not very broad, though rather long. It is more or less roof-shaped, not at all impressed.

The substance of the shell is very thin.

The whole surface of the shell is covered by a very distinct radiating sculpture, crossed at regular intervals by a very fine and closely arranged system of striæ of growth. The radiating sculpture is very variable in its development. Originally, in quite regularly grown specimens, it seems to consist of about 30 rather broad, strong roof-shaped folds, with a sharp rib on top, and narrow valleys between them. These original ribs are, however, in most specimens to a more or less large extent split up into a number of smaller folds intercalated between the larger ones. Only on the anterior part of the shell some of the original ribs are always preserved; but the number of these is very variable, in some specimens nine, whilst in others it is

eighteen. The remainder of the shell surface is covered by less prominent and narrower radiating costæ, which are very irregular in size and very variable in number. The radiating sculpture spreads over the whole of the surface of the shell, and covers the anterior lunula, where it is very fine, as well as the posterior extremity of the shell. The wings also are not exempt from it: on each of them some five or six radiating striæ can be observed.

At the apex the radiating sculpture is very little expressed, this part of the shell being nearly quite smooth.

The hinge apparatus could not be observed on any of the specimens.

The measurements of one right and one left valve are as follows:—

	I.	II.
Entire length of the shell (antero-posterior diameter)	9 mm.	10 mm.
„ height „	9 „	10 „
Thickness of one valve	2 „	3 „
Length of the hinge line	4 „	3·5 „
Apical angle	105°	100°

Locality and geological position.—There were altogether three specimens of this species in the Salt-range collection, two right and one left valves. All three were found by myself at Chidru in the hard yellow sandstone forming the top bed of the upper division of the Productus-limestone. One of the specimens has been broken by me in trying to clean the hinge from the adhering rock.

Remarks.—Though the hinge of this species has not been accessible to observation, yet it seems nearly certain that the species belongs to the genus *Lima*, properly speaking. This genus is, as stated above, not largely represented in palæozoic formations, and thus also the forms with which the present species can be compared are rather limited in number.

The shell which bears the greatest resemblance to the species here under consideration is *Lima retifera*, Schum., from the permo-carboniferous beds of Nebraska, but a distinction between them is very easy. The American shell is larger in size, and has much less numerous radiating costæ, which are all about equal in strength; and besides this it has smooth wings, whilst these are distinctly radiately ribbed in *Lima footei*.

Of the lower carboniferous species of Bleiberg, *Lima haueriana*, Kon., might be compared, but in this shell the radiating costæ are even less numerous than in *Lima retifera*, Schum., though the wings are radiately ribbed like in the present species.

Among triassic species none is known to me which would bear a striking resemblance to the present one.

Family *PECTINIDÆ*.

Genus AVICULOPECTEN, M'Coy.

There is no other family in which it would be so difficult to clear the hinge apparatus from the adhering rock as in the family *Pectinidæ*, and only very rarely is there an opportunity of founding a generic determination within this family upon specimens in which all the internal characters can be observed. The shells belonging to this family are either preserved in very hard limestones in a manner that makes it from the beginning hopeless to clear the hinge apparatus, or, if preserved in other somewhat less hard rock, the shell is so very brittle, that also in this case every attempt to prepare the hinge for inspection must be given up.

Nevertheless in one or the other case it has been possible for me to make the hinge line visible, and from these sporadic cases it appears beyond any doubt that among the materials in hand not only the genus *Aviculopecten*, but also the true genus *Pecten*, is represented. As soon as this fact had been fairly established, it was not difficult to distribute the single species among the two genera, as for each of them there are well known external characters, which make it possible to recognise the genus without being able to inspect the hinge apparatus.

I have, as a rule, considered as belonging to the genus *Aviculopecten* those species having the anterior wing smaller than the posterior one; whilst on the contrary the species, with a very large anterior and a small posterior wing, were considered by me as belonging to the genus *Pecten*.

The genus *Aviculopecten* is considered as an exclusively palæozoic genus. It seems to make its first appearance only in the devonian formation, but already during the carboniferous period it had attained its chief development. The number of species during that period is quite astonishing; in Rigsby's tables alone there are not less than 200 species quoted, and every search in carboniferous rocks furnishes new forms belonging to the genus.

Already in the permian formation, however, the genus appeared to be very reduced in numbers, and it has been quoted from this formation chiefly from American localities, whilst in Europe true species of *Pecten* or *Euchondria* are not rare in these beds; the genus *Aviculopecten* on the contrary is barely at all represented.

In the Salt-range there are not less than nine species belonging to the genus *Aviculopecten*, none of which, I regret to say, can be identified with any European species.

I have only partly been able to re-examine the species of *Pecten* described by de Koninck from the palæozoic deposits of the Salt-range, as of the three species only one has been found among the material I have received for description. Two of these species may belong to the genus *Aviculopecten*, but the third, according to

the development of its ears, is more likely a true *Pecten*. Besides these there occur seven more species belonging to the genus, and I feel quite sure that every search in the palæozoic deposits of the Salt-range will augment this number considerably. In this case, as in the *Pelecypoda* in general, the species which have been detected up to the present represent beyond doubt only a very small fraction of the real number in those palæozoic deposits; they only suggest what these beds may yield to a continued careful search.

Among the new species several groups may be discerned. There is first a group which is very conspicuous by the largeness of the shells belonging to it, as well as the strong, broad, rounded, radiating ribs, separated from each other by sharp, narrow valleys. There is no European species with which this group could be closely compared. In the Keokuk limestone of Illinois there occurs, however, a species which possibly may be considered as the predecessor of the group of forms here under consideration; this is *Aviculopecten indianensis*, M. and W. Another allied species is *Aviculopect. illawarensis*, Dana, from Australia, which is characterised by far less numerous radiating costæ. Though both species exhibit a very similar character of sculpture, yet it is not probable that both should belong to one and the same developmental group or series, and it will be more practicable to take them as the prototypes of two different groups. I thus shall distinguish a group of *Aviculopect. indianensis*, M. and W., with one Indian species *Aviculopect. jabiensis*, W., and another group as "group of *Aviculopect. illawarensis*, Dan.," with two Indian species: *Aviculopect. derajatensis*, W., and *Aviculopect. pseudoctenostreon*, W. Another new species represents a very characteristic mountain-limestone species, and furnishes an interesting link in a whole series of forms; for this series *Aviculopect. fimbriatus*, Phill., must be considered as the type. Another link is *Aviculopect. subfimbriatas*, Vern., and our *Aviculopect. morahensis*, W. n. sp., from the Salt-range belongs to the same series of forms.

A group of forms which is very characteristic for the upper division of the carboniferous formation is that of *Aviculopect. carboniferous*, Stevens, which is best known in Europe under the name of *Aviculopect. hawni*, Gein., or also *Aviculopect. exoticus*, Eichw. This group of forms, characterised by broad, strong, acute ribs, and the strangely cut out and thorned ventral margin is represented in the Salt-range by one species, for which I shall introduce the name of *Aviculopect. subexoticus*, W.

A small species found in the Níla-wán belongs to a group of forms which all more or less resemble *Pseudomonotis*. This group is chiefly distributed in permo-carboniferous strata, and thus species belonging to it have up to the present been chiefly described from America. But also in India, in the Himalaya, the group is represented by *Aviculopect. hiemalis*, Salt., and I take this fossil as the type of the group which I call the group of *Aviculopect. hiemalis*, Salt. The species occurring in the Níla-wán can be identified with one of the species described by

M. de Koninck from the Salt-range, and thus has to bear the name of *Aviculopect. crebristriatus*, Kon.

Another species which I must consider as new is of rather uncertain affinities, as its sculpture is of a not very characteristic pattern. It is an isolated species, and I shall give it the name of *Aviculopect. katwahiensis*, W.

Lastly, there is a small species, which by its very narrow, high form, and concentric sculpture declares itself as a new species. Nor can it be considered as standing in intimate relation to any already described form, and thus it appears also as an isolated form. I will describe it as *Aviculopect. squamula*, W.

One of Mons. de Koninck's species, *Aviculopect. asiaticus*, Kon., has been compared by the learned author to *Aviculopect. plicatus*, Sow., but, as far as can be judged from the drawings, the affinity between the two shells is only a distant one. The other species, *Aviculopect. crebristriatus*, Kon., has just been mentioned above.

According to these indications we are able to group the species of *Aviculopecten* occurring in the palæozoic deposits of the Salt-range in the following manner:—

a. Group of AVICULOPECT. INDIANENSIS, M. and W.
1. *Aviculopect. jabiensis*, W.

b. Group of AVICULOPECT. ILLAWARENSIS, DANA.
2. *Aviculopect. derajatensis*, W.
3. *Aviculopect. pseudoctenostreon*, W.

c. Group of AVICULOPECT. FIMBRIATUS, Phill.
4. *Aviculopect. morahensis*, W.

d. Group of AVICULOPECT. EXOTICUS, Eichw.
5. *Aviculopect. subexoticus*, W.

e. Group of AVICULOPECT. HIEMALIS, Salt.
6. *Aviculopect. crebristriatus*, Kon. sp.

f. Isolated species.
7. *Aviculopect. katwahiensis*, W.
8. *Aviculopect. squamula*, W.

g. Group unknown.
9. *Aviculopect. asiaticus*, Kon. sp.

Of these species, *Aviculopect. jabiensis*, W., *Av. pseudoctenostreon*, W., *Av. subexoticus*, W., *Av. katwahiensis*, W., and *Av. squamula*, W., occur in the upper division of the Productus-limestone; *Av. derajatensis*, W., and *Av. morahensis*, W., in the middle division; and lastly *Av. crebristriatus*, Kon. sp., in the lower division of the Productus-limestone.

Of *Aviculopect. asiaticus*, Kon. sp., the exact position is not known.

a. Group of *AVICULOPECTEN INDIANENSIS*, M. and W.

1. Aviculopecten jabiensis, Waagen, n. sp. Pl. XXIII, fig. 2.

Only the inside of the left valve is accessible to observation; one can, however, judge that it is a characteristic species, which can well be distinguished from other allied forms.

The general outline of the shell seems to have been nearly circular, about as high as broad. The anterior part is somewhat broken, and thus the exact form of the outline cannot be ascertained.

The apex is median in its position, and the margins of the shell are all continuous. There is a very large posterior wing; the anterior wing has been broken off; they seem both to be distinctly marked off from the remainder of the shell. The posterior wing is pointed, and distinctly and broadly emarginated before it reached the posterior shell margin. This latter does not project further than the most prominent point of the posterior wing. Anteriorly very likely the shell margin projected in front of the wing.

The hinge line is very long and straight. As far as it has been preserved, a very distinct furrow stretches along it for the reception of the ligament, no triangular groove for the insertion of the cartilage being present, and thus the position of this shell in the genus *Aviculopecten* is beyond any doubt.

Only the most external layer of the shell seems to be preserved. This is extremely thin, like paper, and reproduces the external sculpture in every detail.

The sculpture can be seen only from the inside, and thus is just the reverse of what it would be if the shell were visible from the outer side. If we describe it as from the outer side of the shell, it consists of numerous, broad, vaulted radiating ribs, which only in very few cases augment by intercalation of a new rib; they simply increase considerably in breadth as they approach the ventral margin, and are separated from each other by very narrow sharp and deep valleys. The number of ribs seems to have been about thirty, but it cannot be stated exactly, as a part of the anterior margin of the shell is broken off. These radiating ribs do not extend to the posterior wing, which is for the most part smooth, with only a very few very thin radiating costæ not far from the hinge line.

The whole shell is covered by very numerous and very closely arranged lamellar striæ of growth, which extend parallel to the shell margin and cross over the radiating ribs as well as over the smooth part of the posterior wing.

The whole shell is nearly quite flat, but very little vaulted.

The dimensions of the only specimen are as follows:—

Entire length of the shell (antero-posterior diameter)	45 mm.
„ height „	48 „
Thickness of the left valve	5 „
Apical angle without the wings	100°

Locality and geological position.—The only specimen of this species that has been found up to the present was collected by myself at Jabi in the upper division of the Productus-limestone in the identical bed in which *Cyclolobus oldhami* and the other Cephalopoda were detected by me.

Remarks.—This species is interesting on two accounts, first, because the furrow along the hinge line for the attachment of the ligament is so very well visible, and thus its position in the genus Aviculopecten is beyond any doubt; and second, because it resembles so very much the American *Aviculopect. indianensis*, M. and W., from the Keokuk group that it becomes not quite easy to distinguish it from that species. The chief differences consist in the general outline and the development of the posterior wing. Whilst in *Aviculopect. jabiensis*, W., the length or antero-posterior diameter of the shell falls slightly short of the height, in *Aviculopect. indianensis*, M. and W., this diameter exceeds the height by some millimetres. In *Aviculopect. jabiensis* the posterior wing is so very large that the shell margin does not project further out than the upper end of the wing; in *Aviculopect. indianensis*, on the contrary, the posterior wing is much smaller, and the posterior shell margin projects far beyond its termination. Besides this, the number of radiating folds is somewhat more considerable in *Aviculopect. indianensis* (about forty) than in *Aviculopect. jabiensis* (about thirty). Thus it appears that the two species are very well distinguishable, though they are very nearly related to one another. Of the two, *Aviculopect. indianensis* is decidedly the older one.

b. Group of *AVICULOPECTEN ILLAWARENSIS*, Dana.

2. Aviculopecten derajatensis, Waagen, n. sp. Pl. XXIII, fig. 1.

This is a largish species of nearly circular outline, thick shell, and with very broad and coarse radiating folds. There are only two right valves available for description.

The apex is about median in its position, obtusely rounded, and not prominent. It is limited on both sides by wings, which are not distinctly marked off from the remainder of the shell. The posterior of these is very large, flat, limited on the upper side by the straight hinge line, pointed, and slightly cut out posteriorly. The posterior shell margin descends from the emargination of the wing directly, being faintly prominent, and forming a very broad and flat arch in uniting with the ventral margin, which is about semi-circular. The anterior shell margin is rather prominent, and ascends obliquely to the very small anterior wing. This latter is not well preserved in any of the specimens. It seems to have been pointed and slightly emarginated, but there is not a trace of a byssal incision observable. On its upper side it is also limited by the straight hinge line.

The shell is not much vaulted, its greatest thickness being situated in the upper third of the diameter extending from the apex to the ventral margin.

The most characteristic feature of this species is the external sculpture of the shell. It consists of 17 or 18 broad radiating folds separated from each other by very narrow and deep valleys. The folds are not sharp, but rounded on their tops, and are covered by very strongly marked lamellose striæ of growth, which are rather irregular, and form broad arches on the tops of the ribs, and angular tongue-shaped processes in the valleys between the ribs. These very likely formed thorny projections at the margin of the shell, but in the specimens at my disposal the margin is not sufficiently well preserved to show these processes entire.

The wings of the shell are devoid of radiating sculpture; but the lamellose irregular striæ of growth, extending parallel to the posterior and anterior margin of the shell, are very distinctly developed on the wings.

The mode of insertion of the ligament on the hinge cannot be observed in any of the specimens at my disposal.

The measurements of a specimen from Kiri are as follows:—

Entire length of the shell	52	mm.
„ height „	48	„
Thickness of the right valve	12	„
Apical angle without the wings	100°-110°	

Locality and geological position.—There are two specimens of this species preserved in the Salt-range collection, both found by Mr. Wynne. The better preserved of the two comes from the trans-Indus continuation of the Salt-range at Kiri. It is preserved in a marbly yellowish-grey crinoidal limestone, very hard, and breaking into splinters. According to the description of the section given in Wynne's report (Trans-Indus Continuation of the Salt-range, Mem., Geol. Surv. of India, vol. XVII, p. 275 (65)) a similar limestone seems to form there the top beds of the middle division of the Productus-limestone. A species of *Pecten* is mentioned by Wynne from sandy beds forming the topmost layers of the Productus-limestone formation. No such fossil, however, preserved in a rock of that description, is among the materials I have received for description.

The other specimen of this species was found by Mr. Wynne at Katwáhi; it is preserved in a white, splintery crinoidal limestone, and comes beyond doubt from the middle division of the Productus-limestone formation.

Remarks.—It is not quite certain whether this species really belongs to the genus *Aviculopecten*, but from the general outline of the shell it becomes highly probable that this is the case.

Though it is probable that the species belongs to the same group, to which also *Aviculopect. illawarensis* must be assigned, yet the similarity between the two species is only a distant one. The Australian species has a much smaller apical angle and less numerous radiating folds than the Indian shell, making a distinction between the two very easy.

A species, however, which bears a very great similarity to *Aviculopect. derajatensis*, W., is *Avicula impressa*, Keyserling, from the permian beds of the Petshora-land. The general habitus of the two shells is nearly identical. Both possess those broad, rounded, radiating folds, separated by narrow sharp valleys; in both, the margin of the shell possesses thorny processes where the valleys reach it; both have a similarly obtuse apical angle, so that a very close relation between the two shells can barely be denied. The differences consist in the less considerable size and less numerous radiating folds in *Avicula impressa*.

Of other species none is known to me which could be more particularly compared to the species here under consideration.

3. AVICULOPECTEN PSEUDOCTENOSTREON, Waagen, n. sp. Pl. XXIII, fig. 7.

Though this species occurs in very great numbers at certain localities of the Salt-range, yet it was extremely difficult to bring away a tolerably well preserved specimen. The description which follows is made up partly from the specimen figured on Pl. XXIII, partly from notes and sketches I made on the spot.

The species is of rather large size, with flat valves, broad, rounded, radiating folds, and nearly circular outline.

The apex is obtuse, slightly anterior in its position, and little prominent. It is limited on both sides by wings, which are not quite equal in size, as the posterior one is somewhat larger than the anterior. In the left valve the anterior wing is obtuse, not emarginated at its base, and marked off from the remainder of the shell by an impression, which extends from the apex to the anterior shell margin. In the right valve the anterior wing is distinctly emarginated, but no proper byssal incision seems to be present. The anterior shell margin forms a broad curve, which projects far in front of the anterior wing, and unites with the ventral margin without proper demarcation. The posterior shell margin is also broadly rounded, projecting further than the posterior wing, and emarginated where that wing commences. The latter is slightly larger than the anterior, and forms about a right angle where the posterior margin unites with the straight hinge line. It is not distinctly marked off from the remainder of the shell.

The hinge line is considerably shorter than the length of the shell. The mode of insertion of the ligament could not be observed.

The shell is provided with broad, well rounded, radiating folds, of which there are about 15 to 17 in one valve. They are separated from each other by equally broad rounded valleys. All the folds originate near the apex, and do not augment in number towards the margin of the shell. They are equally well expressed on the internal cast as on the shell.

All the folds are crossed by shelly lamellæ, representing the stages of growth. These are not all equally strongly developed, some are more conspicuous than others,

by which peculiarity the folds appear, chiefly in certain specimens, somewhat nodose. On internal casts only impressions of the larger of these concentric lamellæ are visible. The wings are without radial sculpture, but the lamellose striæ of growth extend up to the hinge line.

The substance of the shell seems not to have been very thick.

The measurements of the single specimen I have for description seem to have been as follows:—

Entire length of the shell, about	82 mm.
Length of the hinge line, probably	45 „
Entire height of the shell	81 „
Thickness of the left valve	13 „
Apical angle without the wings, about	117°

Locality and geological position.—The species was observed by me to occur very numerously in a section east of Katwáhi, where in the middle of the upper division of the Productus-limestone a whole bed of sandy calcareous rock was filled with its valves, but all the specimens were so much impacted in the rock, that it was absolutely impossible to extract any in a tolerably perfect state. On first seeing those specimens I thought, from their size and bulk, they belonged to the genus *Ctenostreon*, but after a closer inspection I was soon convinced that they were *Aviculopecten*.

At other localities the species seems to be rather rare, and in one place only could I succeed in procuring a tolerably complete specimen. This was also near Katwáhi on the road to Shahpur, where it occurred in a friable sandstone in the middle region of the upper division of the Productus-limestone, together with the species of *Schizodus* and *Myophoria* described in the foregoing pages.

Remarks.—This species is rather nearly related to *Aviculopect. derajatensis*, W., described before. It is distinct from that species by its generally more considerable size, and the broad valleys it bears between the radiating folds which compose the sculpture of this shell, in consequence of which character the shelly lamellæ which cross over the folds do not form in the valleys between them such pointed tongue-shaped processes as they do in *Aviculopect. derajatensis*, and consequently there is not so serrated a ventral margin as very likely existed in that species.

Another species with which the present one must be compared is *Aviculopect. illawarensis*, Dana. All the specimens of this species, which have been figured up to the present, are of much larger size than the Indian shell, but the character of the sculpture is very similar. There are about 20 broad radial folds, separated from each other by similarly broad rounded valleys, but there is always a very striking difference between the two species in the much less considerable apical angle, and thus also in the much less circular outline exhibited by *Aviculopect. illawarensis*.

We thus may consider *Aviculopect. pseudoctenostreon* as a well distinguishable species characteristic for the upper division of the Productus-limestone of the Salt-range.

c. Group of *AVICULOPECTEN FIMBRIATUS*, Phill.

4. Aviculopecten morahensis, Waagen, n. sp. Pl. XXIII, fig. 8.

The general outline of this species is broadly oval, not quite circular. There are only two right valves accessible to observation. These are very flat and provided with very numerous sharp radiating costæ, bearing a characteristic ornamentation.

The apex is about median in its position, not pointed nor prominent, and is limited on both sides by apparently not very large wings, which are, however, not well preserved in any of the specimens at my disposal. The hinge line seems to be much shorter than the antero-posterior diameter of the shell, and thus the anterior as well as the posterior shell margins project far in front and backwards of the hinge line. The shell margins are all continuous and broadly rounded. The wings are marked off from the remainder of the shell by deep furrows. It cannot be stated whether there was a byssal incision on the anterior wing.

The most characteristic feature consisted in the sculpture of the shell. Looked at with the naked eye this seems to be made up of numerous, sharp, radiating costæ, about 33 in number; they are not all of equal strength, but observe an apparent alternation of a smaller with a larger one. All these ribs are crossed by very numerous shelly lamellæ marking stages of growth, and which form broken lines, with the retreating angles on the top of the costæ and the projecting ones in the valleys between. But it is only under the lens that the most characteristic features of the sculpture can be detected. The radiating costæ appear as broad roof-shaped folds, on the top of which a strong rib is visible, and on the declivities on both sides very fine longitudinal striations can be observed. All this system of radial sculpture is crossed by the shelly lamellæ. They form broad ogival vaults on the radiating folds, but the valleys between are so very narrow that the vaults of two succeeding costæ unite in forming a very acute pointed angle.

The substance of the shell is rather thin, not solid. In consequence of this the internal casts are in every way similar to the perfect shell-bearing specimens, only the minute sculpture, which has been described above, and which is so very characteristic, is, as might be expected, absent on internal casts.

There is no perfect specimen accessible to observation, but, as far as can be made out, the measurements seem to have been as follows:—

Entire length of the shell	36 mm.
„ height „	40 „
Thickness of the right valve	5·5 „
Apical angle	90°

The species seems not to have much exceeded these measurements.

Locality and geological position.—There are two specimens (right valves) of this species in the Salt-range collection, both of which were found by Mr. Wynne

at Morah. One of them is an internal cast, the other is preserved with its entire shell. Both are enclosed in a very hard splintery light-grey limestone, and there is but very little doubt that they came from the middle division of the Productus-limestone.

Remarks.—This species belongs to a group of forms which includes very characteristic mountain-limestone species. There is first *Aviculopect. fimbriatus*, Phill., to be compared, but which can readily be distinguished by its less numerous radiating folds. Another allied species is *Aviculopect. subfimbriatus*, Vern., from the mountain-limestone of Peredki in the Valdai. This, on the other hand, has much more numerous radiating folds than the Indian shell, and its distinction is therefore also not difficult.

Already Mons. deVerneuil had drawn attention to the fact that his species was apparently very nearly related to, if not identical with, a shell figured by Portlock under the name of *Pecten ottonis*, Gdf., which does in fact show a great similarity to *Aviculopect. subfimbriatus*, Vern., but just for that reason it is easily distinguishable from our *Aviculopect. morahensis*.

In all the species hitherto mentioned the finer details of sculpture are not known, and thus by the presence of the longitudinal striation with which the radiating folds are covered, *Aviculopect. morahensis*, W., appears to constitute a well distinguishable and perfectly characterised species. Its position in the genus *Aviculopecten* is not quite certain, as the mode of insertion of the ligament could not be observed, but it seems highly probable that the shell here under consideration belongs to M'Coy's genus.

d. Group of *AVICULOPECTEN EXOTICUS*, Eichw.

5. Aviculopecten subexoticus, Waagen, n. sp. Pl. XXIII, fig. 6.

It is from a rather small shell, represented in the Salt-range collection only by a single right valve, that the present species is indicated.

The general outline of the shell is nearly circular, just as long as it is high. The valve is tolerably inflated and covered by rather numerous coarse radiating folds.

The apex is pointed, little prominent, slightly anterior in its position, and well incurved. It is limited on both sides by wings, of which the anterior one is very small, but well defined from the remainder of the shell by a deep furrow. It is pointed at its anterior extremity, but bears, as far as can be observed, no distinct byssal incision, only a sinuation of its anterior margin extending down to the anterior end of the shell. The anterior, ventral, and posterior margins of the shell are all continuous, forming a little more than a semi-circle, and strongly indented in the spaces between the secondary radiating folds, much more so than is indicated in the

drawing. The posterior shell margin passes without proper limit into the margin of the posterior wing. This latter is not very large, but considerably larger than the anterior one. Its posterior margin ascends obliquely, and meets the hinge line under an obtuse angle.

The hinge line is straight and much shorter than the entire length of the shell. The mode of insertion of the ligament cannot be observed.

The surface sculpture of the shell is very characteristic. It consists of twenty-three radiating folds, which are very regularly more and less strong alternately. The principal ribs, of which there are eleven, are broad and rounded on the top, not very high; where they reach the margin, a deep sinuation is formed. Between them equally high, but much narrower, secondary ribs are intercalated, having also no sharp edge at top. Where they reach the margin of the shell blunt thorny processes are formed on the prolongation of the rib.

The ribs are not all straight, but are all slightly bent forwards, so as to form a convex arch towards the posterior side of the shell.

The specimen under description is for the most part an internal cast, and thus nothing can be said as to the finer detail of sculpture of the shell. Only at the two extremities near where the wings unite with the body of the shell traces of shelly substance are observable, and on these parts it appears as if the radiating folds were ornamented on the top with small, distant tubercles, but no distinct observation on these points is possible.

The substance of the shell seems to have been very thin.

The measurements of the only specimen are as follows:—

Entire length of the shell	13 mm.
„ height „	12 „
Thickness of the right valve	3 „
Apical angle, about	106°

Locality and geological position.—The only specimen of this species in the Salt-range collection is a right valve, and was found by myself at Chidru in a very hard yellowish sandstone forming the top bed of the upper division of the Productus-limestone.

Remarks.—On a first glance it would not seem advisable to assign the present species to that group of shells of which *Aviculopect. exoticus*, Eichw., is the prototype. The group has on the whole a very characteristic aspect, and is chiefly conspicuous by its digitate shell margin.

As far as can be judged from the figures of the different shells belonging to the group, two different varieties of form may easily be distinguished, one with sharp roof-shaped radiating folds, having a western (American) distribution, and one in which the radiating folds are rounded, and which seems to be represented chiefly in the eastern hemisphere.

The former variety is typified by *Aviculopect. hawni*, Geinitz, which is most

probably a different species from *Aviculopect. carboniferous*, Stevens. The latter, according to Meek's description, has simple, sharp, radiating folds, whilst the folds of the former are accompanied on each side by a small secondary fold, which gradually becomes indistinct towards the margin of the shell. This character has been described very well by Geinitz, and could also be confirmed by myself when examining Geinitz's original specimens. In the figure given by Geinitz, however, this is not well expressed.

The second variety of form includes the typical species *Aviculopect. exoticus*, Eichw. This shell presents, according to the drawing, broad rounded radiating folds, with equally broad rounded valleys between, in the hollow of which traces of a secondary rib can be discerned. A further development of the same type is represented by our Indian *Aviculopect. subexoticus*, W. The secondary ribs have become here about equal in strength to the primary ones, and extend down to the digitate processes of the shell margin. A very close comparison is, however, not possible, as all the remarks made upon the forms relate to left valves, whilst ours is a right one. Nevertheless it is highly probable that the group characters find expression also on the right valves. A form which seems to be very nearly related to the Indian species is *Aviculopect. hawni*, (Geinitz) Stache (left valve), from the permo-carboniferous deposits of the Alps. If the drawing be correct, the secondary ribs were here developed almost to the extinction of the primary ones, and thus the most prominent radiating folds seem to correspond with the thorny processes of the shell margin and not with the intervals between them.

From these deductions it appears that the Indian *Aviculopect. subexoticus* corresponds with the Russian *Aviculopect. exoticus*, Eichw., from the upper mountain-limestone of the Ural, and very likely stands in developmental connection with this species much more closely than it does with the American *Aviculopect. hawni*.

e. Group of *AVICULOPECTEN HIEMALIS*, Salter.

6. Aviculopecten crebristriatus, Koninck sp. Pl. XXIII, fig. 4; Pl. XXIV, fig. 3.

1863. *Pecten crebristriata*, Koninck: Quart. Journ. Geol. Soc., Lond., Vol. XIX, p. 8, Pl. IV, fig. 5.
1863. *Pecten crebristriata*, Koninck: Fossiles paléozoiques de l' Ind., p. 17, Pl. IV, fig. 5.

The general outline of this rather small species is nearly circular, with tolerably inflated valves and unequal wings. There are only internal casts of this shell available for description, or impressions on the rock of the outer side of the shell. The two valves were different in sculpture.

The apex is about median in its position, slightly prominent, pointed, and incurved. It is limited on both sides by wings, which are not distinctly marked off from the remainder of the shell. The anterior wing is not well preserved in any of the specimens at my disposal. In one of them, a left valve, the anterior

wing seems to stretch rather far down the anterior margin of the shell, and to be limited on its upper side, not by a horizontal, but by a sloping hinge line. There is, however, no distinct observation possible as to the exact shape of this wing.

It seems also to be emarginated on its anterior side. The anterior, ventral, and posterior margins of the shell are all continuous, and form about a semi-circle. The posterior wing is much larger than the anterior one. It is distinctly sinuated on its posterior margin, pointed at its extremity, and limited above by a horizontal straight hinge line. It is identical in shape in both valves.

The two valves are about equally inflated. The substance of the shell seems to have been very thin.

The sculpture is very variable and different in the different valves. In the left valve the radiating lines, of which the sculpture is composed, are very unequal in strength, and not so numerous as in the right valve. They are either regularly alternating, so that always one smaller rib is intercalated between two larger ones, or the larger ribs are less numerous, and there are two to three finer ribs placed between two of the larger sort. All these ribs are crossed by numerous striæ of growth, which are very irregular in strength, but which cannot be observed on the cast. They are chiefly distinct on the wings, where the radial sculpture is developed in shell-bearing specimens only as a few very fine distant, radiating lines. On internal casts the wings are entirely smooth.

The right valve has been figured and described by Mons. de Koninck. It is covered by extremely numerous, very fine radiating striæ, which are not equal in strength, but between which also no distinctly more prominent ones can be discerned. They are very often bifurcating in such a manner that on the top of one of the ribs a furrow appears, which gets gradually deeper, and thus divides the rib in two. Striæ of growth are also very numerous on this valve, but they seem to be finer and less irregular than on the other one. I have no external impression of the wings of this valve. On the casts the posterior wing at least is smooth.

The dimensions of the largest specimen at my disposal, a left valve, are as follows:—

Entire length of the shell	14 mm.
„ height „	15 „
Length of the hinge line, about	11 „
Thickness of the left valve	3 „
Apical angle without the wings	90°

The species seems not to become larger than the specimen of which the measurements are given.

Locality and geological position.—This species is rather common in the Nílawán, where it occurs in a peppery-grey sandstone with very numerous white spots of porcelain earth. In certain parts of the ravine this sandstone forms the very lowest fossiliferous bed of the Productus-limestone formation, immediately above the

thick Lavender-clays. A single small piece of rock I brought from that locality contained not less than seven specimens of this species, mostly left valves. Where Mons. de Koninck's specimen came from is not known. I myself found the species at no other locality.

Remarks.—This species belongs to a small group of forms, which is represented during the carboniferous period in Asia and in America, but which seems to be absent in Europe, unless some triassic shells should be considered to belong to the group.

A species which has been described already a long time since is *Aviculopect. hiemalis*, Salt., from the carboniferous deposits of the Himalaya. This species is not easy to distinguish from *Aviculopect. crebristriatus*, but on the whole it seems to possess a somewhat more pointed and more prominent apex and a less circular outline, as this shell is considerably higher than it is long. Another species which is very nearly related to the one here under consideration is *Aviculopect. curtocardinalis*, Hall, from the Foot-hills in Western North America. In sculpture and general outline this shell resembles *Aviculopect. crebristriatus* so very much that it is very possible the two shells might be identified if specimens were available for comparison. Hall's species was found in permo-carboniferous strata.

Of triassic species *Monotis albertii*, Gdf., the different varieties of which have been recently so well described and distinguished by Noetling, should be compared.

f. ISOLATED SPECIES.

7. AVICULOPECTEN KATWAHIENSIS, Waagen, n. sp. Pl. XXV, figs. 1-2.

The general outline of this species is broadly rounded, about as long as it is high. There is only the left valve known to me, and thus it cannot be stated whether the species has been equivalve or not. The valve accessible to observation is tolerably vaulted.

The apex is median in its position, little prominent, pointed, and barely incurved. It is limited on both sides by large wings, of which the posterior one is the larger. Both wings are distinctly marked off from the remainder of the shell by furrows, of which the anterior one is, however, deeper than the posterior.

The anterior wing is limited on its upper side by the slightly sloping hinge line, is rounded at its anterior extremity, and its outline shows a distinct sinuation just where it unites with the body of the shell. The anterior shell margin is broadly rounded, and projects only slightly in front of the anterior wing. It is continuous with the very broadly arched ventral margin. The posterior margin is more narrowly rounded, and forms a kind of an obtuse posterior angle of the shell, from where the margin ascends in a nearly straight oblique line, which finds its continuation in the furrow separating the posterior wing from the remainder of

the shell. The posterior wing reaches barely further down than the anterior one. It is broadly and flatly emarginated posteriorly, and bears a narrowly pointed posterior extremity, nearly on a line with the posterior extremity of the shell. It is limited above by a horizontal straight hinge line.

The valve is regularly but not strongly vaulted, its greatest thickness being situated about in the upper third of its height.

The surface sculpture of the shell consists of closely arranged, unequal, radiating costæ. There are about fourteen principal ribs, between which generally three secondary ones are placed, of which the middle one is the strongest; in some places five secondary ribs are intercalated. The ribs are tolerably broad and flattened on the top. There are altogether between forty and fifty ribs. On the wings the radial sculpture is much less distinct, but some five radial ribs can be observed. The whole system of radial sculpture is crossed by very numerous and very closely arranged lamellose striæ of growth, which extend parallel to the shell margin and run up to the hinge line. Though they are not all quite equal in strength, yet none are very conspicuous.

The substance of the shell seems to have been very thin.

The measurements of the only entire specimen are as follows:—

Entire length of the shell	21 mm.
„ height „	21 „
Length of the hinge line	17 „
Thickness of the left valve	4 „
Apical angle without the wings	82°

Locality and geological position.—There is one entire left valve and fragments of another specimen of this species in the Salt-range collection. Both were contained in a piece of yellowish-grey friable sandstone collected by myself near Katwáhi on the road to Shahpur, together with all the other bivalves which have been described on the foregoing pages from the same locality. The rock which contained the fossils forms part of the middle region of the upper division of the Productus-limestone.

Remarks.—It would require a prolonged monographical study of the species belonging to the genus *Aviculopecten* to ascertain in what connection the present species stands to other similar forms. There are a number of shells to which the one here under consideration can be compared. As the most similar one, *Aviculopect. ruthveni*, M'Coy, from the mountain-limestone of Dent may be considered; but the character of the sculpture in the Indian shell is considerably different by the flatness of its radiating folds. In this character our shell somewhat resembles *Aviculopect. planoradiatus*, M'Coy. It thus becomes very difficult to decide on the group into which the present species ought to be placed, and I therefore preferred, until better information should be available, to consider it as an isolated one.

8. AVICULOPECTEN SQUAMULA, Waagen, n. sp. Pl. XXIV, fig. 5.

This little shell, of which the right valve only is known to me, has an elongately oval shape, very flat valves and a nearly smooth surface.

The apex is very small, little prominent, pointed, and not incurved. It is limited on both sides by flat wings of unequal shape and size. Both wings are distinctly marked off from the remainder of the shell by deep furrows. The anterior ear is small, truncate at its anterior extremity, and strongly emarginated below. The anterior shell margin is broadly but flatly arched and protrudes far in front of the anterior wing. It is continuous with the more narrowly rounded ventral margin. The posterior margin has about the same shape as the anterior one. The posterior wing is tolerably large and rectangular in its outline. It does not extend as far as the posterior shell margin.

The whole right valve is very flatly arched, its greatest thickness being situated about in the middle of its height.

The substance of the shell is comparatively rather solid.

The surface appears smooth to the naked eye. With the lens, however, a very neat concentric sculpture can be observed, consisting of very numerous and rather high, fine lamellæ, very closely arranged in an imbricating manner parallel to the margins of the shell. This sculpture seems not to extend on the wings.

The mode of insertion of the ligament cannot be observed, but the smallness of the anterior and the largeness of the posterior wing make it highly probable that we have to deal here with a shell belonging to the genus *Aviculopecten*.

The measurements of the only specimen are as follows:—

Entire length of the shell	6·5 mm.
„ height „	8 „
Length of the hinge line	4 „
Thickness of the right valve	1 „
Apical angle without the wings	91°

Locality and geological position.—The only specimen of this species that has been observed up to the present was detected by me in cleaning a specimen of *Streptorhynchus* from the adhering rock. It was the same piece of rock in which also *Septifer squama*, W., was contained. As has been stated already above, this is a hard, pale yellowish-grey sandstone, very likely belonging to the highest beds of the upper division of the Productus-limestone. The locality where it came from is Khund Ghât.

Remarks.—There is a certain group of carboniferous species of *Aviculopecten* to which the present one might be compared, that to which *Aviculop. barandianus*, Kon., *Aviculopect. mundus*, M'Coy, *Aviculopect. circularis*, Kon. (or *mactatus*, Kon.), &c., belong. There is, however, one radical difference between these species and

the one here under consideration, namely, that in de Koninck's and M'Coy's species a faint radial sculpture is present crossing the concentric one, whilst in the Indian shell not a trace of such a sculpture exists.

Of American species *Streblopteria tenuilineata*, M. and W., might be compared; but, not to speak of the circumstance that the Indian shell is certainly no *Streblopteria*, the American species is also much more circular in its outline, and has a less distinct concentric striation.

Thus it must remain undecided to what group of species *Aviculopect. squamula* ought to be assigned, and it will be best to consider it for the moment as an isolated species.

g.—Group *UNKNOWN.*

9. Aviculopecten asiaticus, Koninck. Pl. XXIV, fig. 1.

1863. *Pecten. asiaticus*, Kon.: Quart. Journ. Geol. Soc., London, Vol. XIX, p. 7, Pl. IV, fig. 6.
1863. *Pecten. asiaticus*, Kon.: Fossiles Paléozoiques de l' Inde, p. 17, Pl. IV, fig. 6.

As there is no specimen of this species in the Salt-range collection, and as Mons. de Koninck's original is also not among the specimens preserved in the Geological Society's collection, I can only reproduce here what has been said about this species by Mons. de Koninck himself.

This species, he says, is much larger than *Aviculopect. crebristriatus*, and is a little broader than it is long. It is slightly and tolerably regularly inflated. Its surface is ornamented by 12—15 radiating ribs, which are most conspicuous about the middle of their extent, and vanish partly in the marginal region. In the valleys between two of these ribs 3—5 secondary ribs can be observed, which are by far thinner and less regular than the principal ones, and which are also most conspicuous in the cardinal and central region of the valves. The striæ of growth are barely visible even with the aid of a lens. The wings are small and rectangular. They are covered by a minute striation parallel to the hinge margin. The apex is rather prominent. This species possesses on a first glance a certain similarity to *Pect. plicatus*, Phill., but on a closer examination it will be easy to distinguish the two shells by the small secondary ribs, which are absent in Phillip's species.

The measurements are, according to Mons. de Koninck and in the terms generally used in this work, as follows:—

Entire length of the shell	45 mm.
„ height „	40 „
Thickness of one valve	?

Locality and geological position.—Neither the exact locality nor the exact geological position of this species can be stated. It is only certain that it came from the Salt-range.

Remarks.—It requires some words of explanation why I have placed this species in the genus *Aviculopecten*. The reasons are of a purely negative kind. As the specimen figured by Mons. de Koninck shows only one wing, and thus no indication whatever was available that we had to deal here with a true *Pecten*, and as on the other hand the genus *Aviculopecten* is by far in preponderance over the genus *Pecten* in palæozoic rocks, I thought it more advisable to place this species also in the genus *Aviculopecten*, than to consider it without sound reason as belonging to the genus *Pecten* proper.

Genus: PECTEN, Klein.

It is not usual in recent publications to find the genus *Pecten* in a restricted sense quoted in palæozoic strata. Only the permian formation makes an exception in this respect, as generally the pectinoid shells of that formation are quoted as true *Pecten*. But even in these cases the determination has been questioned by American writers, and, whilst formerly considering those shells as belonging to the genus *Streblopteria*, M'Coy, they now have created a proper genus to receive them under the name of *Euchondria*, Meek. It cannot be doubted that these smooth permian shells are not typical *Pecten*, related to *Pecten varius*, Lin.; and as little can they be united with *Amusium* or *Pseudamusium* on account of their more solid shell and differently developed wings, and thus the creation of a new genus seems to be quite appropriate, the former affiliation of these shells to *Streblopteria* was certainly a mistake.

That there really existed species of true *Pecten* in palæozoic deposits, is, however, proved by several specimens that have been collected by myself and Mr. Wynne in those deposits in the Salt-range. It is partly the development of the wings, which induces me to consider these specimens as belonging to the genus *Pecten*, but partly also the direct observation of the triangular cartilage pit, which confirms the determination in the most decisive manner.

There are not less than five species that I am inclined to assign to the genus *Pecten*, though not for every one of these species can the position be directly proved. But after it had been confirmed beyond doubt that true species of *Pecten* occurred, it appeared highly probable that all those shells in which the anterior wing was larger than the posterior one belonged also to the genus.

The affinities of the shells which I consider to belong to the genus *Pecten* are very difficult to ascertain,—on the one hand, because it is up to the present doubtful whether a transition exists between the generic characters of *Aviculopecten* and *Pecten*, and whether species of *Pecten* can thus be brought into relation with species of *Aviculopecten* or not; and on the other hand, because in the oldest mesozoic formations, Bunt Sandstein and Muschelkalk, no more extensive molluscan

faunas have been detected up to the present, and thus also the relations of the Salt-range species to more recent forms must remain doubtful.

I am therefore not in a position to assign the species I shall have to describe to certain groups of forms, but can only compare each single species to the different shells which they seem more or less to resemble.

The species I shall have to describe are the following:—

1. *Pecten præcox*, W.
2. „ *wynnei*, W.
3. „ *prototextorius*, W.
4. „ *subgranosus*, W.
5. „ *flemingianus*, Kon.

The latter species is not represented in the Salt-range collection, but according to the development of the wings I thought it could not be very wrong to let it remain in the genus to which it had been assigned by Mons. de Koninck.

1. Pecten præcox, Waagen, n. sp. Pl. XXIII, fig. 3.

This little species, of which only one left valve is accessible to observation, has a rather strongly elongately oval outline, depressed valves, a thin shell, and comparatively large wings.

The apex is about median in its position, pointed, very little prominent, and but very little incurved. It is limited on both sides by unequal wings of which the anterior one is considerably larger; it has been partly broken in cleaning the specimen from the adhering rock, but originally it was flat, rectangular, and somewhat sinuated at its base. It is distinctly marked off from the remainder of the shell by an impression or furrow. The anterior shell margin is very flatly arched, and but little more prominent than the extremity of the anterior wing. The ventral margin forms about a semi-circle, and joins without distinct demarcation the posterior margin, which is in shape very similar to the anterior one, being, however, a very little more prominent, on account of the posterior wing being much smaller than the anterior one. The posterior wing also is not entirely preserved, having been partly broken in cleaning the shell. It is also rectangular and slightly sinuated at its base, not very distinctly marked off from the remainder of the shell.

Both wings are limited above by a straight hinge line. On the inside this hinge line shows a barely perceptible furrow stretching along the whole line for the insertion of a ligament. In the centre, below the apex, there is a deep, somewhat oblique, triangular pit for the reception of a comparatively large cartilage. On both sides of the pit the hinge area is perfectly smooth, no teeth being observable. From this it appears beyond any doubt that we have to deal here with a true Pecten.

It is to be regretted that fig. 3 on Pl. XXIII does not bring out all the characters sufficiently clearly.

The left valve, which serves for description, is very little inflated, and the substance of the shell is very thin. The whole surface is covered by very numerous, unequal, radiating striæ or fine little ribs, which augment in number repeatedly by intercalations towards the margin of the shell. Near the margin forty-one of these striæ can be counted, whilst not far from the apex only about twenty are present. The valleys between the ribs are of very unequal breadth. Besides this radiating system of sculpture there is also a concentric one, consisting of very numerous striæ of growth, which are chiefly conspicuous in the valleys between the ribs. Some larger stages of growth are marked by stronger concentric folds. The wings are devoid of radial sculpture. On the anterior one very distinct striæ of growth are visible, which extend parallel to the anterior margin of the wing and terminate at the hinge line. The posterior wing is entirely smooth.

The measurements of the only specimen are as follows:—

Entire length of the shell	7 mm.
„ height „	9 „
Length of the hinge line, about	5 „
Thickness of the left valve	1·5 „
Apical angle without the wings	87°

Locality and geological position.—The single specimen that has served for description is a left valve, and was collected by myself at Virgal in the grey sandstones forming the top band of the upper division of the Productus-limestone.

Remarks.—Among the species of *Pecten* hitherto described, those which have been figured by Stache from the Bellerophon-limestone of the Alps seem to be most nearly related to the shell here under consideration, and among these again the most similar one is *Pecten pardulus*, St. The sculpture consisting of unequal ribs with irregular valleys between them is very similar in both species, but Stache's species is more circular in outline, and thus easily distinguishable; but it is not finally determined as a true *Pecten*, as the hinge apparatus has not been observed. The shape of the wings seems to be very similar to that occurring in *Pecten præcox*.

In America also several species have been described, bearing a sculpture more or less similar to that of the present species; but they all undoubtedly belong to the genus *Aviculopecten*, and thus a closer comparison seems to be unnecessary. All of them can easily be distinguished by differently developed wings, and the greater number have also got a more circular outline and more inflated valves.

2. PECTEN WYNNEI, Waagen, n. sp. Pl. XXIII, fig. 9.

This is a middle-sized species, of which, however, only one left valve is available for description. The general outline is elongately oval, considerably higher than it is long; the valve tolerably vaulted with a conspicuous radial sculpture. The anterior wing very large, the posterior one very small.

The apex is about median in its position, barely prominent, pointed, and very little incurved. It is limited on both sides by wings of very unequal shape and size. The anterior wing is not entirely preserved, but seems to have been very broad, flat, and rounded rectangular. It is distinctly emarginated at its base, and separated from the remainder of the shell by a very broad and very deep furrow. The anterior shell margin is rather narrowly rounded, and not much projecting in front of the anterior wing. The ventral margin is about semi-circular, the posterior rather flatly arched. The posterior wing is very small, not emarginated at its base, and forms an obtuse angle at its upper posterior extremity. It is separated from the remainder of the shell by a shallow furrow.

The hinge line is tolerably long and straight. It has not been possible to observe the mode of insertion of the ligament or cartilage.

The surface of the shell is tolerably strongly vaulted with a deep oblique impression along the base of the anterior wing. The substance of the shell is rather thin.

The whole surface is covered by a very characteristic sculpture, which consists of two systems, one radial and one concentric. The radial sculpture is composed of rather strong, unequal, straight ribs, distributed in groups of three, in which the middle one is the strongest, and is accompanied on each side by a much finer secondary rib. The principal ribs are not all equal in strength, but very often a thinner one is intercalated between two of the larger sort. This is caused by the circumstance that the number of principal ribs or groups of ribs augments towards the margin of the shell by intercalation. The principal ribs are also remarkable by the circumstance that they appear perfectly smooth; even with the lens the striæ of growth cannot be observed on them; this character, however, may be due to the mode of preservation of the shell.

The valleys between these groups of ribs are rather broad and deeply, but roundly, hollowed out. In these valleys the concentric sculpture is very conspicuous and easily observable with the naked eye. It consists in very numerous, sharp, concentric lamellæ which distinctly cross over the secondary ribs, producing small knobs. All these lamellæ are parallel to the shell margin.

On the wings the concentric sculpture is more conspicuous than the radial one. The furrow which separates the anterior wing from the body of the shell is only marked with the concentric sculpture, the single lamellæ forming a sinuated line

and being very conspicuous. On the flat part of the wing a radial sculpture appears again, but is very fine, and chiefly observable in producing a nodulose appearance on the concentric lamellæ. All these latter terminate at the hinge line. On the posterior wing the sculpture is not sufficiently well preserved to state with certainty whether a radial sculpture existed or not.

The measurements of the only specimen are as follows :—

Entire length of the shell	25 mm.
„ height „	31 „
Length of the hinge line, about	15 „
Thickness of the left valve	6 „
Apical angle without the wings	94°

Locality and geological position.—The only specimen, a left valve, of this species in the Salt-range collection was found by Mr. Wynne at Morah. It is preserved in a very hard grey limestone, and comes beyond any doubt from the middle division of the Productus-limestone.

Remarks.—There are a number of species figured by M'Coy which bear a similarly reticulated sculpture as is exhibited by the shell here under consideration. The one which most resembles the present species is *Pect. clathratus*, M'Coy. There is, however, already in the sculpture a certain difference: the valleys between the ribs are much narrower, and the concentric folds more distant from each other in M'Coy's species than is the case in the Indian shell. Besides this, the latter has a more elongated general shape and differently developed wings; in fact, it is a *Pecten*, whilst the other is an *Aviculopecten*.

Of lower triassic species none is known to me, which could be in particular compared with the present species.

3. Pecten prototextorius, Waagen, n. sp. Pl. XXIII, fig. 10.

Though there are three specimens of this species preserved in the Salt-range collection, not one has the whole shell preserved, and thus it is rather difficult to say what the general outline was like. It seems to have been rather elongately oval, with a very large anterior and a smaller posterior wing. A strong radiating sculpture is also characteristic of this shell.

The apex is about median in its position, a little turned towards the front, pointed, very strongly incurved, but not much prominent; it is limited on both sides by wings, of which the anterior one is by far the larger. In the left valve it is flat and separated from the remainder of the wing by a very broad and deep furrow. It is limited above by the straight hinge line. The anterior margin of the wing unites with the hinge line in forming a rounded right angle; below, it is distinctly sinuated, though scarcely so much as is indicated in the drawing Pl. XXIII, fig. 10*a*. In the right valve the anterior wing is also large, flat, and separated from

the remainder of the shell by a furrow, which is, however, not so deep as in the left valve ; at its lower end there is a deep byssal incision.

The anterior shell margin is flatly rounded, and but little more projecting than the anterior extremity of the wing. The ventral margin is not entirely preserved in any of the specimens. It seems also to be broadly rounded. The posterior margin is flatly arched, more flatly than the anterior one, yet it projects much further than the very small posterior wing. This latter is about rectangular in its outline and distinctly separated from the remainder of the shell by a shallow furrow. It is identical in its shape in both valves.

The sculpture consists in both valves of strong radiating costæ of unequal size. Generally they are alternating, chiefly in the middle of the shell, but towards the anterior and posterior margins the ribs become more equally strong and no alternation can be made out. There are altogether about twenty-six ribs, of which the smaller ones disappear towards the apex. The ribs are separated from each other by about equally broad deep valleys.

This whole system of sculpture is crossed by concentric imbricating folds, which form high scaly lamellæ on the top of the ribs, but which can be followed also in the valleys between the ribs. Between these concentric folds a number of striæ of growth are visible.

On both wings a radial sculpture is present. On the anterior one of the left valve this is, however, not more conspicuous than the concentric folds, and thus a very characteristic reticulation is formed, all the points where the two systems of ribs cross each other being marked by highly projecting shelly lamellæ. This mode of sculpture begins already in the furrow, which separates the wing from the body of the shell. On the posterior wing a not very strong fine radial sculpture can be observed.

The sculpture of the anterior wing of the right valve is not known to me.

The valves are both tolerably strongly and equally vaulted. The substance of the shell is very thin.

The dimensions of a left valve from Jabi, as far as they can be taken, are as follows:—

Entire length of the shell	23 mm.
„ height „	?
Length of the hinge line, about	16 „
Thickness of the left valve	6 „
Apical angle without the wings	82°

Locality and geological position.—There are altogether three specimens of this species in the Salt-range collection, all found by myself. One, a left valve, comes from Jabi out of the same bed in which *Cyclolobus oldhami* and the other *Ammonitidæ* occurred; the other, a right valve, was found by me at Chidru, also in the bed of the *Ammonitidæ;* and the third I collected near Katwáhi in the friable sand-

stone which furnished also a number of other Pelecypods. The species thus seems to be characteristic for the upper division of the Productus-limestone.

Remarks.—This species resembles very much certain shells of the mesozoic formations chiefly of the jurassic period, and one would not be in the least astonished to find such a shell in the coral beds of the upper jura. It is, however, I think not necessary to enter here into any closer comparison between those jurassic species and the shell here under consideration; it will be sufficient to look out for similar forms in other formations geologically less far distant from the Salt-range strata than is the jurassic period. There is first in palæozoic beds a shell which is very similar to the present one, namely, *Pecten sclerotis*, M'Coy, from the carboniferous-limestone of Ireland. I have no specimen of this species for comparison, but, as far as can be judged from the figure, the valleys between the radiating ribs are broader, smooth, and flat—all characters which do not exist in the Indian shell—and also the concentric scaly lamellæ seem to be more numerous. The chief distinction, however, consists in the wings, which are different not only in their shape, but which show also just the reverse development in the two species. There can be no doubt that in the Indian shell the large wing is the anterior one, and from this circumstance it becomes also highly probable, though the mode of insertion of the cartilage be not observed, that it is a true *Pecten*. Much less certain is this with *Pecten sclerotis;* it may even be said that most probably it is an *Aviculopecten*. The difference of the two shells is then evident.

In the strata of the Muschelkalk there is a species of *Pecten* not very dissimilar to the present one; it is *Pecten reticulatus*, Gdf. It has strong radiating ribs of alternating strength and crossed by scaly lamellæ, but on the wings the radiating sculpture is absent, and the whole outline is more circular, so that a distinction of this species from the Indian *Pecten prototextorius* is not very difficult.

4. Pecten subgranosus, Waagen, n. sp. Pl. XXIII, fig. 11.

This elegant species is represented in the Salt-range collection by a single right valve, which is about circular in its general outline, little vaulted, with flat unequal wings, and a fine radial sculpture.

The apex is slightly anterior in its position, little prominent, pointed, and little incurved. It is limited on both sides by wings, of which the anterior one is very large, the posterior one seems to be rather small. Both are marked off from the remainder of the shell by deep furrows. The anterior one is not entirely preserved, but from what remains it can be seen that it possessed a very deep byssal incision at its lower end, and that its anterior margin was very likely cut off obliquely, so that the upper part of the wing was more projecting than the lower one. The margins of the shell are all continuous, and form together a nearly circular outline. The anterior margin is but little projecting in front of the wing, but the posterior

margin bends rather far out. The posterior wing is broken off for the greater part, but seems to have been rather small.

The most characteristic feature of the shell consists in the sculpture. This is composed of extremely numerous, fine, unequal radiating ribs, about eighty in number, covering the whole shell. They augment considerably by intercalation in approaching the margin, and thus one or two smaller ribs may be observed between two larger ones. The valleys between the ribs are about as broad as the ribs themselves. All the ribs are not smooth, but very finely and very closely granular, so as to appear under the lens like strings of very fine beads. The formation of these granules is apparently caused by a concentric system of sculpture crossing the radial one, but the granules are so very irregular in their distribution that it is not possible to discern distinctly concentric lines in their arrangement. Only on the anterior wing the concentric system of sculpture is somewhat more distinct, and especially in the furrow separating the wing from the remainder of the shell is it conspicuous as fine lamellæ forming a row of receding arches. On the wing itself a combination of the radial and concentric sculpture produces again numerous fine granules arranged in radiating lines.

The posterior wing is almost entirely broken off, and thus its sculpture cannot be observed.

The valve is very regularly and moderately vaulted; the substance of the shell is thin.

The measurements of the only existing specimen are as follows:—

Entire length of the shell	46 mm.
„ height „	53 „
Thickness of the right valve	7 „
Apical angle without the wings	87°

Locality and geological position.—The only specimen of this species in the Salt-range collection was found by Mr. Wynne in the trans-Indus continuation of the Salt-range, at Bilot. The bed from which the specimen came is not marked on the label, and in Wynne's report no species of *Pecten* is mentioned in a special bed. The rock in which the specimen is contained is a light-coloured, nearly white, very hard calcareons sandstone, or sandy limestone with ferruginous partings. This condition of the rock seems to correspond best with some layers mentioned by Wynne in the upper division of the Productus-limestone at Bilot.

Remarks.—There are but very few species to which the present one can be compared. It is beyond doubt a *Pecten*, as appears from the very strong development of the anterior wing, though the insertion of the cartilage cannot be observed, and thus only species of *Pecten* ought to be taken into consideration for a comparison. However, there is no species of *Pecten* known to me within palæozoic or lower triassic rocks, which could be compared to the present one, and only some forms of *Aviculopecten* bear a certain resemblance to it. *Aviculopect. granosus*, Sow.,

may be first mentioned. The sculpture of both shells is rather similar, though Sowerby's species seems to bear in certain varieties coarser radiating ribs, but in other varieties again there are as many as eighty ribs, all finely granular or nodulose. There are, however, very considerable differences in the wings, as the anterior wing is very small and the posterior one undefined, just the reverse of what occurs in *Pect. subgranosus*. Also the apical angle is considerably different; it is as much as 125° in Sowerby's species, whilst it is only 87° in ours.

Of M'Coy's species *Pecten* (*Aviculopect.*) *fallax* and *Lima decussata* may be compared. The former is easily distinguishable by the development of its wings, but the latter requires further notice. How M'Coy came to consider this species as a Lima, if we may take the figure as correct, is difficult to understand. If the figured specimen were the right valve of a true Pecten, an opinion that is not altogether excluded, it would be rather similar to the present species. The radial striation is, however, somewhat finer, and the anterior wing different in shape.

In America, as far as is known to me, no species occurs, which could be in particular compared to the present one.

5. Pecten flemingianus, Koninck. Pl. XXIV, fig. 2.

1863. *Pecten flemingianus*, Kon.: Quart. Journ. Geol. Soc., Lond., Vol. XIX, p. 7, Pl. IV, fig. 4.
1863. *Pecten flemingianus*, Kon.: Foss. Paléoz. de l' Inde, p. 17, Pl. IV, fig. 4.

As there is no specimen of this species in the Salt-range collection, and Mons. de Koninck's original is also not among the materials preserved in the collection of the Geological Society, I can only repeat here what has been said about this shell by Mons. de Koninck.

This species, he says, is of a middle size, longer than it is broad, and has a sub-oval general outline. Its surface is ornamented with a small number (8-9) of radiating ribs, which are little prominent. The space between the ribs is nearly quite smooth, and there are only very indistinct striæ of growth to be observed, barely visible with the naked eye. The wings are small, of triangular shape, and have a smooth surface.

The measurements, expressed in the terms generally used in this work, are as follows :—

Entire length of the shell	14 mm.
„ height „	16 „

Locality and geological position.—There is no mention made by Mons. de Koninck as to the exact locality where the shell came from. As also the condition of the rock in which the specimen is contained is not indicated, it is impossible to guess what geological position the species may have occupied.

Remarks.—I have already explained in the introduction to the genus *Pecten* why I introduce this species under the heading *Pecten*.

As to the affinities of this species, no indication is given by Mons. de Koninck.

Genus Euchondria, Meek.

The smooth species of *Pecten* from the permian formation have for a long time been a puzzle to palæontologists, as they would not fit into any of the recently created genera.

They could not be well considered as species of *Aviculopecten*, as most of them have the anterior wing larger than the posterior one, and to consider them as true *Pecten* would not do on account of the smooth condition of their shells. *Pseudamusium*, *Entolium*, *Syncyclonema*, were then attempted, but for these genera the shell of the fossils under consideration was mostly too solid in its structure and too much inflated, and the wings show markings of a radiating sculpture; so that at last it was unavoidable to create a new generic designation.

It had been proposed by Meek to use the name of *Streblopteria*, M'Coy, for these shells; but it is not probable that such a proceeding would be correct, as the forward obliquity of the shell is much less apparent in the forms here under consideration, and because the posterior wing is always distinct in these forms, whilst it is continuous with the body of the shell without the slightest demarcation in *Streblopteria*.

The genus *Euchondria* has been proposed for *Pecten neglectus*, Gein., as typical species; but I think that though the posterior wing in *Euch. neglecta* is somewhat larger than the anterior one, yet the permian species like *Pect. pusillus*, Schl., etc., might far better be united wtih *Euchondria* than with *Streblopteria*.

The internal arrangement of the hinge with its cartilage has not been observed in any of the permian species, and it is also not visible in the shell I shall have to describe from the Salt-range.

As far as is known up to the present, the genus has a very small geological range, as it seems to be restricted to the upper coal measures of America and the permian beds of Europe, unless forms like *Pecten consimilis*, M'Coy, ought also to be considered as belonging to it.

From the palæozoic deposits of the Salt-range I have to describe a single species as probably assignable to this genus.

1. Euchondria subpusilla, Waagen, n. sp. Pl. XXIV, fig. 4.

This neat little species is represented in the Salt-range collection only by one right valve, the general outline of which is transversely oval, flat, with a smooth surface.

The apex is about median in its position, a little turned towards the front, pointed, and not prominent. It is limited on both sides by unequal wings, which are distinctly marked off from the remainder of the shell by furrows. The anterior wing is the larger one, obtusely rounded at its extremity and distinctly sinuated at its base. The anterior margin is comparatively narrowly rounded and projecting very far in front of the wing. The ventral margin is very flatly arched, and joins the broadly rounded posterior margin without demarcation; it projects far beyond the termination of the posterior wing. This latter is very small, triangular in its shape, and terminating posteriorly in an obtuse angle.

The hinge line is straight and tolerably long. The mode of insertion of the cartilage cannot be observed.

The valve is not much vaulted; its substance is comparatively solid, not transparent.

The surface of the shell is quite smooth, and even with the lens very fine striæ of growth can only with difficulty be detected. Only some few of them are stronger and form concentric folds, whick mark larger stages of growth. The wings also are nearly quite smooth; the fine horizontal grooves seen in the magnified drawing on the anterior wing have apparently only been marked by the needle in cleaning the shell of the adhering rock. There are, however, very faint traces of a *radiating* sculpture present on this wing.

The measurements of the only specimen are as follows:—

Entire length of the shell	8 mm.
„ height „	6 „
Length of the hinge line	4 „
Thickness of the right valve	1 „
Apical angle without the wings	118°

Locality and geological position.—The only specimen of this species that has been found up to the present is a right valve, which was collected by myself at Virgal in the grey sandstones which form there the top band of the upper division of the Productus-limestone.

Remarks.—There are several forms to which the present one can be compared among the species which I consider to belong to the genus *Euchondria*. First, the typical species, *Euchondr. neglecta*, Gein., requires a close comparison. It also is a very small species, about the same size as *Euch. subpusilla*, W., but it can without difficulty be distinguished by its shorter and higher general outline, the larger wings, of which chiefly the posterior one is very large, and the distinct radiating lines found on them.

Another species to which a certain similarity is presented by the shell here under consideration is *Euchondr. pusilla*, Schl. sp., from the German Zechstein. This species becomes slightly larger than the Indian shell, but the development of the wings is similar, only the anterior wing has a more distinct byssal incision in the

German species. Also the transversely oval shape of the Indian fossil is a point of difference, but this might possibly partly be caused by pressure. On the whole, the similarity between *Euchondr. pusilla* and *Euchondr. subpusilla* is greater than that between the latter species and *Euch. neglecta*. But also in America (upper coal-measures) there is a species very similar to *Euch. pusilla* as well as to *Euch. subpusilla*, this is *Euchondr.* (*Streblopteria*) *tenuilineata*, Meek. It can be distinguished from our *Euchondr. subpusilla* by the same characters by which the latter differs from *Euch. pusilla*.

There have still to be mentioned two shells of the Salt-range collection of which no description can be given here. The one is an *Ostrea* or *Terquemia* attached to specimen of *Streptorynchus*, and too badly preserved to allow of an exact description. The occurrence of such a shell is, however, of sufficient interest to be noticed even in so badly preserved a specimen.

The other is a shell which has been described by Mons. de Koninck under the name *Anomia lawrenciana*. This shell is not at all rare in the Salt-range, but I shall give a description of it only later on in this work, as this very curious fossil is certainly not a Pelecypod, but either a Brachiopod or a coral; which of the two I am not quite certain, as I have not yet succeeded in cleaning completely the inside of the shell.

Pro vince : MOLLUSCOIDA.

Class : BRACHIOPODA.

Order : ARTHROPOMATA.

Family : *TEREBRATULIDÆ.*

The *Brachiopoda* are the most numerous among all the fossils occurring in the Productus-limestone of the Salt-range, and the materials of this class in my hands are so extensive, that it will be possible to add several new observations to the stock of knowledge already in our possession regarding these fossils.

It is however a matter of much controversy in what manner such observations ought to find expression, whether they should take form by the creation of new genera and species, or whether they should merely be used to illustrate the relations between different groups of the class as now imagined.

It cannot be denied, that in the systematic arrangement of the Mollusca in general, there has in recent times prevailed a tendency to restrict the large generic groups, resolving them into a number of smaller and more sharply defined genera, which should at the same time serve to bring out more clearly the changes the Molluscs have undergone in time, so as to unite under one generic heading those forms which are not very far separated from each other in time. This tendency had its beginning with the American palæontologists, whilst the sharper distinction of genera amongst the recent Mollusca was inaugurated by the brothers Adams.

There is no obvious reason why the *Brachiopoda* should be excluded from the tendency now prevailing among men of science in relation to the Mollusca proper, the less so as the shells of *Brachiopoda* require even sharper distinction than do the shells of Mollusca. Any one who has ever had to determine the shells of *Brachiopoda* must know, that in certain groups, for instance, in the group of the *biplicate Terebratulæ*, it is nearly impossible to determine a species without knowing the formation from which the specimens came; and even if this latter fact be known, it requires the utmost carefulness and the observation of the most minute characters to distinguish the different species and arrive at a satisfactory specific determination of these shells.

A most striking instance of the difficulties that surround the determination of such shells is furnished by a species that occurs in the Salt-range, and which has been described by Mr. T. Davidson as *Terebratula biplicata*, Brocchi, var. *problematica*. This shell exhibits in a very striking manner the external characters

of *biplicate Terebratulæ*, and, led by these external characters, Mr. Davidson suggested that this species came from mesozoic (probably cretaceous) strata, and that thus also this formation was apparently represented in the Salt-range. As a matter of fact the shell comes from the Productus-limestone, and has nothing whatever to do with *Terebratulæ biplicata*, Brocchi. To make out this fact it was only necessary to investigate the internal structure of the shell. All the European palæozoic *Terebratulæ* have an internal structure which deviates by certain very constant peculiarities from the structure of the mesozoic shells. Just the same peculiarities which characterise the European palæozoic *Terebratulæ* are also exhibited by the Indian species, and thus it becomes evident that this shell also is of palæozoic age. Now it is not likely that any one in the world would pretend that he knows the *Brachiopoda* more thoroughly than the celebrated palæontologist of Brighton, yet even he has been misled by the external form. Had a more minute generic grouping existed at the time of the description of this shell, and had it been unavoidable to ascertain at least some of the internal characters of such a shell in order to effect an exact generic determination, such a mistake would have been impossible, as the author would immediately have known that he had to deal with a palæozoic species.

By such occurrences it is strikingly demonstrated how useful the distinction of more limited generic groups in reality is ; so it must be considered as a most meritorious undertaking on the part of M. Bayle, as well as by M. Douvillé, to split up the old genus *Terebratula* into several new generic groups, or at least to advocate the retention of the generic groups already created by King and others, but which had been considered until very recently as simple synonyms of *Terebratula*.

Douvillé's remarkable paper starts from the consideration of the mode of development of the internal appendages in the shells of recent *Terebratulidæ*, and comes to the conclusion that, according to this development, two large divisions should be distinguished ; one comprising the forms with a long loop, to which should be added those forms like *Terebratella* or *Megerlea*, in which the loop is doubly or trebly joined to the valve; and another division comprising the shells with a short loop. The author wishes to consider the two groups as separate families for which he introduces the names of "*Waldheimidæ*" and "*Terebratulidæ*." I do not think it practicable thus to destroy the old family *Terebratulidæ*, which seems to be so well founded, and has been so excellently defined. It will be quite sufficient for the purpose of bringing out the significance of these groups to consider them as subfamilies, for which I wish to introduce respectively the names of "*Terebratulinæ*" and "*Waldheimiinæ*."

If however subfamilies are once introduced, the other genera which cannot be comprised in the two preceding subfamilies must also be brought under similar headings. There is not much that I can suggest in this direction. A limited group seems to be indicated by some forms, of which *Centronella*, Billings,

might be taken as the type. They have no cardinal process in the smaller valve; the loop is of medium size, very simple, and without recurring branches, but it seems not to be sufficiently known in all the forms apparently belonging to the group. These forms might nevertheless be conveniently united in a subfamily bearing the name of *Centronellinæ*. The subfamily is also represented in the Salt-range. A fourth subfamily might be formed by the genera *Meganteris*, Suess, and *Rensselæria*, Hall, but I cannot say anything positive on this point.

The geological distribution of the different subfamilies thus established is very different. The oldest are apparently the *Waldheimiinæ*, which seem to include the oldest forms of all the *Terebratulidæ*. The form to which I allude is *Terebratula melonica*, Barr., from upper silurian strata of Bohemia. The general arrangement of the internal appendages in the smaller valve seems, according to M. Hall's figures,[1] not quite dissimilar to that prevailing in *Macandrewia*, King. In the larger (ventral) valve there are two very long dental plates, whilst in the smaller or dorsal valve the sockets for the reception of the teeth of the other valve are supported by two plates extending in an oblique direction from the bottom of the valve up to the sockets, and for which I shall introduce the name of septal plates, as, if their direction is very oblique, they unite in the middle and form together a distinct septum. These plates are of great importance for the classification of the *Terebratulidæ* in general. The loop is long, reaching more than halfway down to near the front of the shell. It possesses two long recurring branches, which unite by a slender transverse piece. The peculiar feature that seems essentially to distinguish this loop from that of *Macandrewia* is the position of the spurs which support the oral opening of the animal so very far from the apex of the shell. According to Douvillé's method this form should probably receive a proper generic designation, and might perhaps belong to the genus *Cryptonella*, Hall, but the transverse band on the crura uniting them near their origin on the dorsal side has not yet been observed. Be this as it may, there is no doubt that the subfamily *Waldheimiinæ* was already represented during the upper silurian period, after the detection by Mr. Davidson of two species, which he described under the names of *Waldheimia mawei* and *W. glassi* from the soft Wenlock shales. Though these species be very minute, and Mr. Davidson may prefer to quote them only with a query under the heading of *Waldheimia*, yet the drawing of the loop represents so undoubtedly a form belonging to the subfamily, the external shape of the shell recalling already the general form of *Antiptychinor* and *Aulacothyris*, that the representation of the subfamily in upper silurian strata can barely be doubted. In the carboniferous formation also, a species has been detected which undoubtedly agrees in all its characters with the typical species of the *Waldheimiinæ*. This shell occurs in the carboniferous deposits on the Rio Tapajoo in Brazil, and has been described by Mr. O. A. Derby under the name of *Waldheimia continhoana*. The loop which he figures leaves

[1] Hall's 16th Report of the New York State Museum, 1863, reproduced in Barrande's Système Silurien de la Bohème, vol. V, pl. 141.

no doubt as to its family relations, and the species might with great probability be attributed to the genus *Zeilleria* of Bayle. *Terebrat. bovidens*, Mort., is also said to possess a long apophysary system, but this has not been figured up to the present.

In the older palæozoic epochs, together with the typical forms just mentioned, there occur in somewhat greater numbers some forms of shells which also belong very likely to the subfamily *Waldheimiinæ*, but which have been distinguished by Hall under the name of CRYPTONELLA, Hall (1861, fourteenth Report of the New York State Museum, p. 21; Pal., New Y., Vol. IV, p. 392, pl. LXI). This genus is characterised by a very long loop with long recurring branches. The crura near their origin on their dorsal side are united by a transverse shelly band. Of the characters of the hingeplate nothing is known; there seems to be no septum. In the ventral valve dental plates seem to be present. So far as is now known the genus is restricted to the silurian and devonian periods.

From the trias upward, the *Waldheimiinæ* begin to get numerous; but it is only in jurassic times that they begin to be split up into a number of different genera. Of these the following may be mentioned :—

PLESIOTHYRIS, Douv. (Bull. Soc. Géol. de France, 3 ser., Vol. VII, p. 275, 1879) : dental plates in the ventral, and a septum in the dorsal valve; loop long, free; general form biplicate.

ZEILLERIA, Bayle (Expl. Carte Géol. de France, Vol. IV, Atlas pl. IX, 1878) : dental plates in the ventral, and septum in the dorsal, valve; loop long, free; general form with a straight frontal line.

AULACOTHYRIS, Douv. (Bull. Soc. Géol. de France, 3 ser., Vol. VII, p. 277, 1879) : ventral valve carinate, with dental plates; dorsal valve sinuate, with a septum; loop long, free.

ANTIPTYCHINA, Zittel (Handb. d. Palæont., p. 704, 1880) : ventral valve with dental plates and two strong folds in the frontal part; dorsal valve with a septum, a sinus in the frontal region with a fold in the middle; loop very long, free.

EUDESIA, King (Perm. Foss., p. 144, 1850) : internal arrangement as in Zeilleria; shell strongly plicated.

TEREBRATELLA, Orb. (Pal. Fr. Terr. Crét., Vol. IV, p. 110, 1847) : loop long, but not free, affixed to the cardinal plate as well as to the septum.

MEGERLEA, King (Perm. Foss., p. 81, 145, 1850) : loop trebly attached.

Of these genera only one is restricted to the jurassic period, viz., *Eudesia*, King; all the others extend also into cretaceous strata. Here, however, a number of new genera is added. Of these may be mentioned—

LYRA, Cumberl. (Sow. Min. Conch. pl. 138, f. 4-6, 1816).

TRIGONOSEMUS, Kœnig (Icones Foss. Sectil., p. 3, pl. IV., f. 73, 1825).

KINGENA, Davidson (Mon. Brit. Cret. Brach., p. 42, pl. IV, f. 15-28, 1852).

MAGAS, Sow. (Min. Conch. II., p. 39, pl. 119, f. 1-5, 1816).

RHYNCHORA, Dalm. (Kongl. Vet. Acad. Handl., 1827, p. 105);

which are all sufficiently well knowu so that their diagnosis need not be repeated here.

In the actual period MACANDREWIA, King; NEOTHYRIS, Douv.; and WALDHEIMIA, King, further augment the number of genera, not to speak of MAGASELLA, Dall; FRENULA, Dall, *etc.*

One strange fact, however, cannot be passed in silence, that the appearance in time of the genera belonging to the subfamily *Waldheimiinæ* is very little in accordance with what one might expect according to the laws of development.

The individual development of the recent *Waldheimiinæ* has been studied by Friele, Dall, *etc.*, and it has been found that the internal apparatus of the recent species undergoes a number of changes before it attains the shape and arrangement of the adult specimens. The first stage that has been observed is an arrangement of the loop, very similar to that occurring in adult specimens of the genus *Magas*. In the further development of the specimens of *Waldheimiinæ* the very large septum is partly re-absorbed, and then appears a stage which is most similar in its loop to that existing in adult specimens of *Terebratella*; and only after a further partial absorption of the septum, and other changes in the loop, does the permanent shape of the loop of *Waldheimiinæ* appear, and the specimen is at last full grown. If now the development of the individual only repeats the development the whole family has taken, we should expect to find that the geologically oldest representatives of the subfamily should exhibit a loop similar to that of *Magas*, and that the long and free loop of *Waldheimia* ought to appear only in later geological periods. But just the reverse is the case. The geologically oldest representative, *Terebr. melonica*, Barr, has a long, free loop; and even if this species should prove to belong to the genus *Cryptonella*, this would not materially alter the fact. Even if we exclude the genus *Cryptonella* from the discussion, yet we find already in the upper silurian period (the Wenlock shales), a shell which in all important characters agrees with the jurassic *Antiptychina* or *Aulacothyris*, having a well developed, long and entirely free loop. The first species of *Terebratella* have up to the present been observed to occur in jurassic strata, whilst *Magas* does not occur earlier than in the cretaceous period. The mode of development the single individuals of the recent *Waldheimia* undergo is thus rather to be termed a retrograde than a progressive one.

The subfamily *Terebratulinæ* was already well developed in the devonian period, though forms belonging to it were not very numerous. Some of these devonian species seem to belong already to the genus *Dielasma* of King, whilst others seem to form part of a new genus, which has also many representatives in the Salt-range. The subfamily has been considered up to very recent times as being composed only of two genera, *viz.*, *Terebratula* (*Dielasma*, King, having been considered as synonymous) and *Terebratulina*. It has been shown by Douvillé not only that the genus *Terebratulina* was in a more close relation to *Terebratula* than to any other genus, the two thus forming one family (or subfamily), but also that the enormously large number of forms included in the old genus *Terebratula* could very conveniently be subdivided into a number of generic groups.

Douvillé founds his classification partly on the external form of the shells, partly on the presence of dental plates or of a septum; but to him the fact was not yet known that in the *Terebratulinæ* the septum is only produced by the junction of the two septal plates, and that it is a mere matter of degree whether the septal plates are so oblique in their direction as to join and form a septum, or whether they are less oblique and meet the bottom of the valve before reaching the middle of it. This latter fact has been clearly brought to light by the very careful investigations of the rhætic *Brachiopoda* and their allies by M. Zugmeyer. Therefore not only the septum but also the existence of septal plates is a factor of great importance in the classification of the *Terebratulinæ*.

If we apply these principles of classification to the mass of shells which have hitherto been considered to belong to the genus *Terebratula*, we come to the following generic subdivisions:—

Terebratulina, Orb. (Ann. Sc. Nat. VIII, p. 249, 1847): shell finely striated radially; loops short, free, forming a closed circle: jurassic to recent.

Terebratula, Klein (Tentamen methodi ostracologicæ, p. 171, pl. XI, nr. 74, 1753): shell biplicate; loop short, free; not annular, without septal plates; no dental plates in the ventral valve. *Liothyris*, Douv., can barely be considered but as a subgenus of *Terebratula*, since young specimens of *Terebratula*, as has been rightly remarked by Zittel, would very often have to be considered as *Liothyris*, whilst the adult forms would be *Terebratula*: (? devonian) triassic to recent.

Rhætina, Waagen, n. gen.: shell biplicate; loop short, fixed to the bottom of the valve by septal plates, which sometimes form a septum, sometimes not; ventral valve without dental plates. Type: *Terebratula gregaria*, Schafh. from rhætic beds: rhætic.

Dielasma, King (Nat. Hist. Rev., Vol. VI, p. 519, 1859)=*Epithyris*, King (*non* Phillips): shell biplicate or simply vaulted on the frontal line; loop short, fixed to the bottom of the dorsal valve by septal plates, which form sometimes a distinct septum (see Davidson Monogr. Perm. fossils, pl. I, figs. 18-20); very strong dental plates in the ventral valve: devonian to trias.

Zugmeyeria, Waagen, n. gen.: shell biplicate; loop short, without septal plates; strong dental plates in the ventral valve. Type, *Terebrat. rhætica*, Zugm.: rhætic.

Coenothyris, Douvillé (Bull. Soc. Géol. de France, 3rd ser., Vol. VII, p. 281, 1879): shell with a vaulted frontal line; loop short, fixed to the bottom of the dorsal valve by strong septal plates, which mostly unite to form a strong and tolerably long septum; transverse part of the loop, uniting the recurving branches, forms a flat shield; in the ventral valve dental plates are developed in young specimens, which are however re-absorbed in adult ones: muschelkalk.

Pygope, Link. (Handb. Phys. Erdbeschr., Vol. II, part 1, p. 451, 1830): dorsal valve with a mesial impression, ventral valve with a fold; the mesial part, occupied by the sinus in the dorsal valve, often stops in growth, whilst the lateral parts continue augmenting in size, thus forming a perforation in the shell; the loop

is very small and free; neither septal nor dental plates exist. It seems to me perfectly reasonable in Zittel to unite Douvillé's genus *Glossothyris* with *Pygope*, as the distinction between the two genera seems to be only a matter of degree: jurassic and lowest cretaceous.

DICTYOTHYRIS, Douvillé (Bull. Soc. Géol. de France, 3rd ser., Vol. VII, p. 268, 1879): plication of the valves the reverse of that occurring in the *Biplicatæ*; the dorsal valve with two impressions, and the ventral one with two folds; loop short and free; neither septal nor dental plates; surface of the shell mostly finely striated radiately: jurassic and lower cretaceous.

HEMIPTYCHINA, Waagen, n. gen.: surface of the shell smooth, or irregularly folded in the frontal region; frontal line vaulted; loop short like in *Terebratula*; with distinct septal plates, which very rarely unite to form a septum. Type, *Terebr. himalayensis*, Davids. It seems that the jurassic forms (as *Ter. plicata*, Buckm., *T. fimbria*, Sow., etc.,) resembling *Hemiptychina* are distinct from the palæozoic shells by the absence of septal plates; they would then very likely have to be considered as forming a distinct genus.

DIELASMINA, Waagen, n. gen.: shell strongly but irregularly folded radially, internal arrangement as in *Dielasma*. Type: *Diel. plicata*, W. n. sp.

It may perhaps be desirable to bring the above-mentioned genera into a tabular arrangement, similar to that given in Douvillé's paper in the Bull. Soc. Géol. de France, 3rd ser., Vol. VII, p. 263. They would then have to be arranged in the following manner:

	LOOP SHORT.				
Annular—by the union of the oral processes. Neither dental nor septal plates.	NOT ANNULAR—BY THE DISUNION OF THE ORAL PROCESSES.				
	Neither dental nor septal plates.	Only dental but no septal plates.	Only septal but no dental plates.	Septal and dental plates.	
Terebratulina, Orb.	*Terebratula*, Kleiu.	*Zugmeyeria*, Waagen.	*Rhætina*, Waagen.	*Dielasma*, King. *Cœnothyris*, Douv.	*Biplicatæ.*
	(Nov. gen?)	.....	*Hemiptychina*, Waagen.	*Dielasmina*, Waagen.	*Fimbriatæ.*[1]
	Pygope, Link.	.....	.....	.....	*Nucleatæ.*
	Dictyothyris, Douv.	.....	.....	.....	*Coarctatæ.*

By far the greatest number of forms belonging to the family *Terebratulidæ* is included in the two subfamilies treated of on the foregoing pages; there are however yet remaining a small number of generic groups which do not fit into these two subfamilies, and which in part at least can be considered as forming distinct subfamilies. Already above I have shortly hinted that yet two more subfamilies

[1] I use the name of "*Fimbriatæ*" for those forms which never are truly biplicate, but smooth in the young state, and more or less strongly and irregularly plicated when adult. Example: *Terebrat. fimbria*, Sow.

may be distinguished, which may respectively be termed "*Centronellinæ*" and "*Meganterinæ*." Within these two subfamilies all the remaining genera of *Terebratulidæ* (except quite doubtful ones like *Vitulina*, Hall, *Leptocœlia*, Hall, etc.) can be brought. Only for one genus does the systematic position remain doubtful; this is *Hynniphoria*, Suess.

There is a genus of *Terebratulidæ* in the Salt-range for which I propose to introduce the name of *Notothyris*. It is very difficult to assign a place in the system for this genus, as its internal arrangement is not yet entirely known. The most characteristic feature of its internal appendages is that the hingeplate in the dorsal valve bears a distinct oval foramen in the umbonal region. The loop seems not to have been complete. On the whole it seems not improbable that these shells are more or less nearly related to *Centronella*, and I thus shall put this genus into the subfamily *Centronellinæ*.

Subfamily: *TEREBRATULINÆ*.

Genus: DIELASMA, King.

There are not many writers up to the present who would have accepted this genus as well founded and would have kept it entirely apart from *Terebratula*. It cannot be denied that its affinity to *Terebratula* is very great; but if we observe how very constant the characters are by which it can be distinguished from the true *Terebratulæ*, and how the occurrence of these characters is limited to certain formations, it must be admitted that the distinction of the genus is of great practical value and of the utmost importance at least to the geologist, who finds in the dental and septal plates of such indifferent forms as the *biplicate Terebratulæ* a most convenient clue for the determination of the geological age of the beds containing such fossils.

The characters of *Dielasma* are very easy to be recognised. They consist in the general terebratuloid form of the shell; a short loop like in *Terebratula*, fastened near its origin to the bottom of the smaller or dorsal valve by two plates, which extend in a more or less oblique direction from the sockets for the reception of the cardinal teeth towards the middle line of the dorsal valve, forming sometimes a septum. The umbo of the smaller valve bears a distinct cardinal process. In the larger or ventral valve the cardinal teeth are supported by very strong dental plates. The existence of these dental plates as well as of the septal ones can easily be made out by scraping off a little of the shell on the beak as well as in the umbonal region of the smaller valve; the plates will then soon appear as dark lines, converging towards the termination of the beak as well as towards the apex of the smaller valve.

The genus was already distinguished by King in the year 1850, but at that time the author thought it possible to utilise the old name of *Epithyris* (given by Phillips to all the *Terebratulæ*) for this particular group, and thus he introduced

the forms belonging to the genus under the name of "*Epithyris*, Phillips." The same view of the matter is also taken by Dall, who accepts the name *Epithyris* for these forms, but writes "*Epithyris*, King" not Phillips. Now, in reality, King never created a genus under the name of *Epithyris*; he only used Phillips' denomination in a wrong sense. It thus seems incorrect to apply the name of *Epithyris* to this group; as it cannot be admitted that a name should be used in science in a sense quite different from that attributed to it by the author who created it. It seems therefore that King was quite correct in creating a new name for the forms here under consideration, and in doing so he very likely acted upon the same considerations as have led me to adopt his name *Dielasma*.

M'Coy, in his "British Palæozoic Fossils," thought proper to apply the name *Seminula*, which he had formerly given to other shells, to the species which form now the genus *Dielasma*; but, as in the original diagnosis of *Seminula* only those shells were comprised which belong to the families *Rhynchonellidæ* and *Spiriferidæ*, it does not seem advisable to transfer the name now to shells belonging to the *Terebratulidæ*; thus, from this consideration also, the name *Dielasma* will have to stand.

The genus seems to commence in the devonian period, but it does not appear to have been very common then. *Terebrat. lincklaeni*, Hall, seems to belong to it, but otherwise many species do not seem to occur. The chief development of the genus is during carboniferous and permian times, in which till quite recently no other forms were known to exist. Already in the trias the genus seems to become again very scarce, and in the upper region of this system, the Kössen beds, it is entirely replaced by *Rhætina*, Waagen, and *Zugmeyeria*, Waagen; so that in these beds no traces of *Dielasma* are any longer found. Also in jurassic and cretaceous times the genus is entirely absent.

Among the forms of *Dielasma* occurring in Europe in carboniferous and permian strata, probably not less than six series may be distinguished; it seems however to be such a heresy to utter this opinion that I must dwell with some words more on the point. According to the views now greatly prevailing, all the shells which, in my opinion, may be grouped into six series, do not form more than one species. This species not only comprises all the carboniferous, but also the permian forms of *Terebratulidæ*, and has to be called *Terebrat. sacculus*, Martin. If we now review all the forms that come within the range of this name, we find that we have first the large forms, with a straight, not vaulted, frontal line, *Terebrat. hastata*, Sow., which would have to be counted among the 'Cinctæ' of Leop. von Buch and Quenstedt. The same would occur with a small form with vaulted valves and a more or less emarginated front, the *Terebr. sacculus*, Mart., in a restricted sense, and perhaps *Terebr. sufflata*, Schloth. Then come the forms with a vaulted frontal line—*Terebr. ficus*, M'Coy; *Ter. virgoides* (M'Coy) Dav.; *Terebr. sp.*, Dav., Mon. Brit. Perm. Brach., pl. 1, fig. 18; *Terebr. hastæformis*, Kon.; *Terebr. plica*, Kutorg; *Terebr. Gillingensis*, Dav.; *Terebr. elongata*, Schloth, etc.; which

would all have to be counted with the "*Biplicatæ*" of Leop. v. Buch and Quenstedt. Lastly there come the forms with a concave frontal line like *Terebrat. vesicularis*, Kon., which forms part of the "*Antiplicatæ.*" All these forms now make up the one species *Terebrat. sacculus*, Mart. If now we find in any work the species *Ter. sacculus*, M., quoted as occurring in any particular bed, do we obtain by such a quotation the slightest idea what form really occurs? Or is it indeed quite irrelevant what form we have to deal with, or what form occurs just in that particular bed? Certainly not. The names which we apply to objects in nature have all been invented for the sole purpose of conveying to us concrete ideas of the objects themselves, but this point is absolutely lost, if we subsume such a number of forms to one name. A species of so monstrous an extension as is *Terebr. sacculus* (Mart.), Davidson, is absolutely useless for stratigraphical as well as for biological purposes; and if in every class of animals a similar extension were to be given to the species, we should soon have to renounce all the more exact stratigraphy and all our historical account of the development of the animal kingdom, resulting from an exact observation of the stratigraphy in connection with the minute distinction of the animal forms.

But there decidedly exist intermediate forms between all the above-mentioned species or sub-species, or whatever we like to call them; and a perfect transition can be traced from one form to the other. It cannot be doubted, and the standard of thorough study and excellent power of observation exhibited by all the works of Mr. Davidson is an absolute security for this, that the transitional forms really exist, and that all the fossils mentioned under the above names are all most intimately connected together; nevertheless, I must retain the opinion that these fossils have all to be considered as distinct species. Any one, who has collected Brachiopods in large numbers in the field, will have made the observation that in this class of Molluscs, more than in other classes, transitional forms between different species occur, and that such transitional forms are chiefly numerous in certain groups, for instance in the biplicate *Terebratulæ*, more than in others. That such transitional forms occur between species which are of different geological age is only natural, and depends upon the mode of development of the species; but also between contemporaneous species transitional forms exist. In this latter case, the distribution of the transitional forms is very unequal; in some localities many of them occur, in others they are only very sparingly represented or even entirely absent. This mode of occurrence seems now to be in direct proportion to the number of specimens of each species which are found in each locality. In places where very great numbers of individuals of two species are heaped together, transitional forms are more numerous; in other localities, on the contrary, where two species occur, but not in great numbers, transitional forms are rare or even entirely absent. This seems to indicate a circumstance which has not up to the present been sufficiently taken heed of. In localities where two species in very great numbers were crowded, there seems to have been great possibility for the production of hybrids, whilst in

other localities where the two species were not so numerous few or no hybrids were produced, and thus in the cases of contemporaneous species the transitional forms might for the greater part be due to hybridity. But the production of hybrids cannot establish identity of species. It can thus, I think, very well be sustained that, even if transitional forms exist, yet two fossils of different shapes might very well form different species, and thus we come back to the old axiom that every form that can be fixed and distinguished from others by description and figures, has to be considered as constituting a species, though this must be understood "*cum grano salis.*"

To return then to our starting point, I must repeat that the retention of more concise species can very well be sustained on biological grounds, and that it is an absolute necessity for the field-palæontologist ('paléontologue voyageur' as the French would say) to have more concise species, as he cannot speak for instance on the permian formation of *Terebr. sacculus,* because on the one hand forms exactly resembling the typical *sacculus* do not occur at all, on the other hand, because the form which really in great numbers do occur have not even the slightest resemblance to the typical *Ter. sacculus.* Identical shapes may be picked out among a great number of specimens, as was done by Mr. Davidson, and that such specimens should occur is only natural, and can easily be explained by atavism, but the average form of the *Terebratulæ* occurring in each formation is perfectly sufficiently distinct to keep the two sets of shells separate as distinct species.

Starting from such considerations it seems to me that the more generally known European species occurring in the carboniferous and permian formations may be grouped in the following manner:—

I.—Group of Dielasma hastatum, Sow.
II.—Group of Dielasma ficus, (M'Coy), Dav.
„ sp. nov., Dav., Mon. Brit. Perm. Brach., Pl. I, fig. 18
III.—Group of Dielasma sacculus, Mart.
„ sufflatum, Schloth.
IV.—Group of Dielasma gillingense, Dav.
„ elongatum, Schloth.
V.—Group of Dielasma virgoides, (M'Coy). Dav.
VI.—Group of Dielasma vesiculare, Kon.

By the true *Dielasma ficus,* M'Coy, with its undulating frontal line, the existence of one more series might be indicated, but I cannot say anything positive about it. Of these series three pass up into the permian formation, whilst three others seem to be restricted to carboniferous strata.

In the Salt-range the genus *Dielasma* is rather largely represented, and the existence of several of the series of forms which have been just indicated as

distinguishable among the European species, can be recorded also in India. There are altogether ten species of *Dielasma* in the Productus-limestone of the Salt-range, which may be grouped in the following manner:—

I.—Group of Dielasma sacculus, Mart.
1. *Dielasm. guttula*, W., n. sp.

II.—Group of Dielasma gillingense, Dav.
2. *Dielasm. elongatum*, Schloth. sp.
3. „ *nummulus*, W., n. sp.

III.—Group of Dielasma ficus, (M'Coy) Dav.
4. *Dielasm. truncatum*, W., n. sp.
5. „ *minor*, W., n. sp.
6. „ *itaitubense*, Derby.

IV.—Group of Dielasma biplex, W.
7. *Dielasm. biplex*, W., n. sp.
8. „ *breviplicatum*, W., n. sp.
9. „ *acutangulum*, W., n. sp.
10. „ *problematicum*, (Dav.) W.

The last of these groups is one which is not represented in Europe, though it might stand in a certain relation to the group of *Dielasm. virgoides*, (M'Coy) Dav.

On the whole, the affinity of the species of *Dielasma* occurring in the Productus-limestone of the Salt-range is more with permian than with carboniferous species. Not only that one of the forms can be identified with the permian *Diel. elongatum*, Schl., but also *D. guttula* and *nummulus* can only be compared to *D. sufflatum*, Schloth. and *D. elongatum*, Schl., respectively; and even the whole group of *D. biplex* seems to be most intimately connected with *D. elongatum*. The form *D. acutangulum* so closely resembles elongated varieties of Schlotheim's species that I formerly did not think it quite improbable this shell may turn out to really belong to that species.

Of the other forms *D. truncatum*, W., is quite singular, and has not been observed anywhere else, whilst *D. Itaitubense*, Derb., was originally described from beds in Brazil which, according to the other Brachiopods occurring in them, will have to be considered as being about on the same level as the upper coal-measures of North America.

I.—Group of *DIELASMA SACCULUS*, Mart.

1. Dielasma guttula, Waagen, n. sp., Pl. XXVIII, fig. 14.

This very small species is about similar in size and form to a grape seed, inflated, rounded, with a small adpressed beak and a straight frontal line.

The ventral or larger valve is considerably more strongly inflated than the smaller one, and this holds good as well in the longitudinal as in the transverse direction. Posteriorly it is produced into a beak, which is in comparison to the

size of the shell rather thick, but not long, and bent distinctly over. It is pierced not quite at its extremity, but just posteriorly to it, by a tolerably large oval foramen. The beak is shut in below by a very indistinct false area, which can barely be called such, so much does it pass all round imperceptibly into the sides of the valve. The beak is so firmly adpressed to the apex of the smaller valve that it cannot be observed whether deltidial plates were present or not.

The smaller or dorsal valve is much flatter than the ventral one; it is, however, also very regularly vaulted. Both valves meet all round in a nearly perfectly straight line.

The surface of the shell is covered by numerous rather strong striæ of growth. The punctation of the shell cannot be very distinctly seen, as the shell is not very favourably preserved for the observation of this character. As far as it can be made out, the punctation seems to have been rather coarse.

Of the internal characters nothing can be seen, even the existence of dental plates remains doubtful. The shell has been placed by me in the group of *Diel. sacculus* on account of the general similarity which it exhibited to the species belonging to that group.

The measurements of the only existing specimen are as follows :—

Entire length of the shell	6 mm.
Length of the smaller valve	5 „
Entire breadth of the shell	4·5 „
„ thickness of the „	4 „
Apical angle of the larger valve	62°

Locality and geological position.—The only specimen of this species was collected by myself at Amb at the very base of the compact limestones forming the middle division of the Productus-limestone.

Remarks.—This little shell may possibly be the fry of some other large form, and thus the propriety of its description as a distinct species may properly be doubted. It is however pretty certain that this shell is not the young of any of the species I shall have to describe, and thus it may pass as indicating the existence of a distinct species, of which the adult form may possibly yet be discovered. But this may just as well be a small species, of which the dimensions may never become much larger. This is a point which can only be cleared by further discoveries.

As far as can be judged from the little specimen available, it does not seem that this form is identical with any of the European species. The small specimens figured by Davidson, Mon. Brit. Carb. Brach., Pl. II, figs. 1, 2, have a much smaller and less stout beak, and it is almost beyond doubt that by the small specimen from the Salt-range a different species is indicated. There is a somewhat greater resemblance to young specimens of *Diel. sufflatum*, Schl. sp. as figured by Davidson, Mon. Brit. Perm. Brach., Pl. I, figs. 11, 12, 13; but they differ in that the dorsal valve of the Indian specimen is much flatter than that of the specimens figured by

Davidson, and that the whole shell is covered by strong imbricating striæ of growth, which do not exist in the permian specimens. On the whole I feel justified in considering this shell as a distinct species, which is, however, most nearly related to *Diel. sufflatum*, Schloth.

II.—Group of *DIELASMA GILLINGENSE*, Dav. sp.

2. Dielasma elongatum, Schloth., sp., Pl. XXV, fig. 10.

1816. *Terebr. elongata, et complanata*, Schloth.: Denkschr. Acad. München, Vol. VI, p. 27, pl. VII, figs. 7, 8, 9, 13, 14.

1850. *Epithyris elongata* (Schloth.) King : Monogr. Perm. Foss. of England, p. 147, pl. VI, figs. 30-45.

1858. *Terebratula elongata* (Schloth.) Davidson : Monogr. Brit. Perm. Brach., p. 9, pl. I, figs. 5-7, 14, 19-22.

1861. *Terebratula elongata* (Schloth.) Geinitz : Dyas, p. 82, pl. XV, figs. 14-28.

1870. *Terebratula elongata* (Schloth.) Quenstedt : Petrefactenkunde Deutschlands: Brachiop ., p.425, pl. 50, figs. 104-116.

The general outline of this shell is slightly pentagonal, considerably longer than it is broad ; the beak is small and adpressed, pierced just at its apex by a not very large, round foramen ; the line in which the two valves meet is tolerably straight and only little vaulted in the frontal region.

The larger, or ventral, valve is a little more strongly inflated than the smaller one; its curve is very regular, the greatest thickness being a little below the middle of the length of the shell. Anteriorly it is slightly produced and bent up, forming the slightly vaulted frontal line. The beak is small and well bent over, limited on its lower side by an indistinct area, which is shut in on the upper side by indistinct ridges starting from below the foramen and extending to near the lateral parts of the valve. The beak is so firmly adpressed to the smaller valve that nothing can be seen of deltidial plates. The foramen is round and not large.

The smaller, or dorsal, valve is a little more flattened than the ventral one; nevertheless it is distinctly arched longitudinally, and in this respect resembles more that of *Dielasma sufflatum* than that of *D. elongatum*. The apex is pointed and slightly bent in.

The surface of the shell is smooth and only few striæ of growth are distinctly visible. The punctation of the shell can only be observed in some places with the lens. It appears that the shell bears a kind of epidermis which covers up the punctation, and only when this epidermis is removed can the punctation be seen. It is very much like that of *Diel. elongatum* figured by King, very close and very fine.

Of the internal characters of this shell nothing can be seen, nor can they be made out for the present, as no large materials of this species are available. There is, however, but very little doubt that it bears the characters of the genus *Dielasma* in general, as in outward appearance it resembles so closely other species of the genus that an internal similarity may be expected.

The measurements of the figured specimen are as follows :—

Entire length of the shell	18 mm.
Length of the smaller valve	16 „
Entire breadth of the shell	14 „
„ thickness „ „	8·5 „
Apical angle of the larger valve, about	79°
„ „ „ smaller valve	110°

Locality and geological position.—There are altogether three specimens of this species preserved in the Salt-range collection : one collected by myself at Katta in the very lowest beds of the compact limestones forming the middle division of the Productus-limestone (bed Nr. 12 of my note-book) ; two others were also found by myself at Amb in a black, coaly sandstone forming the lowest fossiliferous bed of the lower division of the Productus-limestone at that locality.

Remarks.—The general form of this shell is rather similar to *Diel. sufflatum*, Schloth. sp., and resembles chiefly the variety figured by King on pl. VII, figs. 6, 9. Nevertheless I do not think that this shell should be considered identical with that species of Schlotheim, as several points of difference exist which make a distinction not only easy but even necessary. In the Indian shell the median depression, which extends from near the beak to the frontal region, corresponding to the bend in the frontal line is totally absent ; the valves are both less inflated, and the general form of the shell is altogether more elongated than in *Dielasm. sufflatum* ; but just by all these characters it agrees with *Diel. elongatum.* Of carboniferous species, *Diel. gillingense* must chiefly be compared ; but, after a careful examination of the figures, it seems directly impossible to unite the Indian shell with that carboniferous form. The highly characteristic flatness of the dorsal valve is absolutely wanting in the Indian shell, and, thus, the two forms cannot possibly be considered identical. On the other hand, if we compare the figures of *Diel. elongatum*, for instance that on Pl. VI, fig. 37 of King's monograph, or Pl. I, fig. 7 of the monograph of Mr. Davidson, the similarity of these figures to the one on our Plate XXV is so striking that it cannot be doubted that the specimens represented by all these figures belong to one and the same species. If I were to adopt Mr. Davidson's view in the matter, I would have to quote the Indian shell, not as *Diel. elongatum* but as *Terebratula sacculus*, Martin, as both these forms belong to one and the same species. But what would be the use of such a quotation ? The simple mention of a name like *Ter. sacculus*, a thoroughly carboniferous species, would immediately suggest a carboniferous age for the beds in which it occurs, and yet the form which, in fact, occurs, has not the slightest similarity to the average form of *Terebratulæ* occurring in carboniferous strata ; on the contrary, it can only be more particularly compared to the average form of *Terebratulæ* occurring in permian beds. Thus the quotation of *Diel. sacculus* in the Salt-range would simply be misleading as to the probable age of the beds in which this fossil occurs as well as to the real affinities exhibited by the specimens. This is a most striking example, how necessary the more minute

distinction of the species for the proper determination of the age of a bed may be; though I will not say that, by the occurrence of *Diel. elongatum* in the Productus-limestone, these beds will irrevocably pass into the permian formation.

3. Dielasma nummulus, Waagen, n. sp., Pl. XXV, fig. 9.

This species is in its general form closely related to *Diel. elongatum*, Schloth. sp., but yet differs so far from it in several important characters that I think it more correct to describe this shell as a distinct species.

The general form is nearly circular, very little elongated, and in no way pentagonal; both valves are flattened; the beak is small and distinctly bent over; the frontal line nearly straight and but very little raised in the middle.

The ventral valve is not quite regularly vaulted, as, longitudinally, the curve from the end of the beak to about the upper third of the length of the valve is rather abrupt, and from there it is rather gradually tapering to the frontal line. The beak is truncated just at its extremity by a round, and not very large foramen. From both sides of the foramen to the lateral parts of the shell two indistinct ridges descend in a gentle curve, marking off an indistinct false area. The beak is so firmly adpressed to the apex of the dorsal valve that it cannot be seen whether deltidial plates are present or not.

The dorsal valve is even more flattened than the ventral one, and is nearly quite circular in its outline, the apex being but very little projecting. The line in which the two valves meet is very nearly straight all round.

The surface of the shell is entirely smooth, and even with the lens barely any striæ of growth can be seen. The punctation is excellently preserved in the specimen under description, but it is so fine that it becomes almost microscopical, and can only be observed with a very powerful lens, and is much finer than that of *Diel. elongatum*.

In the only specimen I have for description nothing can be seen of the internal characters.

The measurements are as follows:—

Entire length of the shell	21 mm.
Length of the dorsal valve	19 „
Entire breadth of the shell	18 „
„ thickness „	9 „
Apical angle of the larger valve	80°
„ „ „ smaller „	114°

Locality and geological position.—The only specimen of this species that has hitherto been found was collected by myself at Katta in the very lowest beds of the compact limestones forming the middle division of the Productus-limestone (bed Nr. 12 of the section in my note-book).

Remarks.—This species belongs beyond any doubt to the group of forms to which also *Diel. elongatum* belongs; nevertheless I do not think that it should be

united with that species. The greatest difference consists in its nearly circular form, and in this respect it resembles more nearly *Terebratula lata*, Schloth., which is, however, by most authors also considered only as a variety of *Dielasm. elongatum*. There is, moreover, always a further marked difference in that the present species is quite rounded, whilst *Ter. lata* is more or less distinctly pentagonal. The sinus, too, in the larger valve is more strongly developed in Schlotheim's species than in the Indian shell, where it is nearly quite absent. Another marked difference consists in the lateral aspect of the shell, where the line in which the two valves meet is nearly quite straight in the Indian shell, whilst it is distinctly curved in *Terebr. lata*. This character indicates a different transverse curvature in the dorsal valve of the two species. Thus it seems to me probable that a distinct species is represented by the Indian specimens.

III.—Group of *DIELASMA FICUS*, (M'Coy) Davidson.

4. Dielasma truncatum, Waagen, n. sp., Pl. XXV, figs. 11, 13.

This rather large species has a somewhat pyriform general shape, is elongated, truncated in the frontal region, with a somewhat vaulted frontal line, and a very thick beak, which is strongly bent over, and bears a large oval foramen.

The larger, or ventral, valve is very strongly inflated, most so in the region near the beak, gradually tapering towards the frontal line. A short distance, however, before reaching it, it is abruptly deflected at an obtuse angle and ascends to meet the dorsal valve. The longitudinal curve of the valve is thus first (near the beak) nearly semicircular, then flattened, and at last geniculated. In the transverse direction this valve is considerably flattened in the middle and suddenly bent up on both sides. The beak is very thick and short, and strongly bent over. The foramen is oval, situated not quite on the apex of the beak, but somewhatbehind it, a position which is similar to that occurring in *Ter. bovidens*, Morton. From both sides of the foramen indistinct ridges extend down the beak, marking off a very ill-defined false area.

The dorsal valve is about as much inflated as the ventral one, but its curve is more regular. From the apex to near the frontal line it is very regularly vaulted; it is then suddenly deflected and bends down upon the ventral valve. Transversely this valve is much more strongly vaulted than in the longitudinal direction.

The sculpture of the shell consists only in not very numerous and not very strongly developed striæ of growth. The punctation of the shell is very fine, as fine as in *Diel. elongatum*.

Of the internal structure of the shell only the very strongly developed dental plates can be seen. Of the septal plates or the loop nothing can be seen.

In young specimens the inflation of the valves is much less considerable, and the truncation in the frontal region is entirely wanting.

The measurements of two specimens are as follows:—

	I.	II.
Entire length of the shell	35 mm.	12·5 mm.
Length of the smaller valve	29 „	11 „
Entire breadth of the shell	22 „	9·5 „
„ thickness „	19 „	5·5 „
Apical angle of the larger valve	51°	56°
„ „ „ smaller „	63°	75°

Locality and geological position.—There are only two specimens of this species preserved in the Salt-range collection, which were both found by myself at Amb in a black, coaly sandstone forming part of the lower division of the Productus-limestone. From the same bed a great many specimens of Chonetes were obtained, so that I called the bed "Chonetes bed" in my note-book.

Remarks.—This shell, when full grown, is very singular in its shape, and cannot easily be mistaken. It resembles none of the hitherto described forms more particularly, though it cannot be denied that it stands in a certain relation to *Diel. ficus* as figured by Davidson, Mon. Carb. Brach., Pl. I, fig. 13; the great inflation in the region of the beak is similar in the two species, but the development of the frontal region is peculiar in the Indian shell. In young specimens distinctive characters are not displayed, so they resemble *Diel. elongatum* or *Ter. bovidens*; they seem, however, to be distinct from these shells by a somewhat smaller apical angle.

Another species which might be compared is *Diel. plica*, Kutorga. The typical form of this species, as figured by Kutorga, shows very little resemblance indeed, but V. v. Möller in his monograph of the carboniferous Brachiopods of the Ural, besides the typical form which is represented Pl. I, fig. 3 of the monograph, figures another variety which he considers to belong also to *Ter. plica*, but which very likely represents another species, and to which figs. 4, 5, and 6 will correspond. This species is in general outline very similar to *Diel. truncatum*, but can be distinguished by an impression extending all along the ventral valve from the beak to the front, and by the sharper margins, chiefly in the frontal region.

5. Dielasma minor, Waagen, n. sp., Pl. XXV, fig. 12.

Together with the species just described there occurs another shell, which in most respects agrees with *Diel. truncatum*, but which is distinct by its shorter and comparatively broader form, larger apical angle and much less considerable size.

The general form of this shell is somewhat pentagonal, the greatest breadth being situated about in the middle of the length of the shell, from there it tapers towards the beak as well as towards the front. Both valves are about equally inflated, the larger one more so in the region of the beak, the smaller one more in the frontal region. The beak is very short and very thick, perfectly rounded, distinctly bent over and pierced a little behind its apex by a very large oval foramen. The false

area on both sides of the beak is very small and indistinct, and not even by the slightest indication of ridges is it limited off from the remainder of the shell.

The front of the shell is remarkable by its truncation, which is similar to that of the preceding species, and is produced by the sudden deflection of both valves all round towards the line in which the two valves meet. In the smaller valve the apex is very distinctly elevated, and there extends a ridge from the apex to the front, which broadens and flattens as it approaches the frontal region. On both sides of the apex the valve is strongly depressed and then spreads wing-like to its largest transverse extension. This feature is not well expressed in the drawing Pl. XXV, fig. 12*a*.

Of the internal characters of this shell nothing can be seen. The granulation of the shell substance is in this species still closer and finer than in any of the preceding ones; in fact, it is so fine that it can only be seen under very favourable circumstances.

The measurements of the only specimen are as follows:—

Entire length of the shell	19 mm.
Length of the smaller valve	16 „
Entire breadth of the shell	15 „
„ thickness „	10·5 „
Apical angle of the larger valve	78°
„ „ smaller „	123°

Locality and geological position.—The only specimen of this species that has been found up to the present was collected by myself at Amb in the lower division of the Productus-limestone in the so-called *Chonetes*-bed of my note-book, together with *Dielasm. truncatum*, W.

Remarks.—It appears probable that this species is only a variety of *Diel. truncatum*; still, there are such marked differences between them, and transitional forms have not been detected up to the present, that I prefer until more complete materials will be available, to consider the two shells as representing different species.

The characters by which the two species can well be distinguished consist in the shorter, broader, and more pentagonal form of *Diel. minor*. The apical angle in this latter shell is much more considerable than in *Diel. truncatum*, and it exhibits the characters of the full-grown shell (the truncation of the valves all round) of a size at which specimens of *Diel. truncatum* must still bear a sharp frontal line; it is thus probable that *Diel. minor* was always of a much smaller size than full-grown specimens of *Diel. truncatum*.

Of other than Indian shells none can be particularly compared to the present species. *Terebr. bovidens*, Mort., is not quite dissimilar; chiefly the beak bears a certain resemblance, but the peculiar truncation of *Diel. minor* is absent in the American shell.

6. Dielasma itaitubense, Derby, sp., Pl. XXVI, fig. 5.

1874. *Terebratula itaitubensis*, Derby, Bull. Cornell Univers. (Science), Vol. I, No. 2, page 1, pl. II, figs. 1, 3, 8, 16; pl. III, fig. 24; Pl. VI, fig. 15.

The species is of rather large size, elongated, flattened, with sharp margins and a not very large beak.

The ventral valve is flattened, broad, elongated, oval. The beak is distinctly bent over, not very thick, long and entirely free, not adpressed to the apex of the dorsal valve. The foramen is triangular, and apparently piercing just the apex of the valve; it is not very large, and appears to be limited on its lower side by small deltidial plates. From both sides of the foramen very sharp and distinct ridges originate, producing the triangular shape of the foramen; they descend in a slight curve to the lateral parts of the valve, thus marking off a rough, but rather distinct false area. In the frontal line the ventral valve is only very slightly produced, causing the frontal line to ascend a little and to form a very slight arch. This arcuation of the frontal line appears in the specimen which serves for description much stronger than it is in reality, owing to a malformation in the specimen in the process of fossilisation, as can be well seen from the cracks in the shell. As the specimen has been exactly copied by the artist, this arcuation of the frontal line is equally exaggerated in the figure.

The dorsal valve is also flattened, more strongly arched in the transverse than in the longitudinal direction, and a little bent up in the frontal region, according to the arcuation of the frontal line.

Of the internal characters of this shell nothing can be seen. Nevertheless it is highly probable from the near relation it seems to exhibit to *Diel. hastatum*, Sow., that it belongs to the genus *Dielasma*.

The substance of the shell exhibits under the lens very distinctly a close and fine granulation, which is, however, not so fine as in the species described on the foregoing pages.

The measurements of the only existing specimen are as follows:—

Entire length of the shell	41 mm.
Length of the smaller valve	38 „
Entire breadth of the shell	31 „
„ thickness „	14 „
Apical angle of the larger valve	62°
„ „ „ smaller „	85°

The thickness as measured is probably too small, as the specimen has suffered somewhat from pressure; it may very likely be as much as 16 mm.

Locality and geological position.—The only specimen of this species that is contained in the Salt-range collection was found by myself in black calcareous beds at Nursingpahár, on the limit between the middle and lower divisions of the Productus-limestone.

Remarks.—From all the forms of Brachiopods that have hitherto been described out of carboniferous deposits, *Ter. itaitubensis* from Brazil is the only one that can be particularly compared to the Indian shell just described, and it seems to be so far identical in all its characters to our Indian fossil that I thought it proper to apply the above name also to the latter.

The most striking characters the species possesses consist in the considerable flattening of both valves towards the frontal region, the very slightly arched or nearly straight frontal line, and the overhanging and strongly carinated beak. The Indian specimen is somewhat broader in comparison to its length than the specimens that have been figured by Derby from Brazil, but this single difference seemed to me not sufficient to distinguish the Indian shell as a separate species.

Of other species *Dielasma ficus*, M'Coy, is most nearly related, but can easily be distinguished by its much more inflated valves, and non-carinated beak. *Diel. cymbæformis*, Dana, from Australia has very nearly the same characters as *Diel. ficus* but is distinguished from this species chiefly by its more broadly ovate form and the concentric undulations of the shell. From *Diel. itaitubense* it can be distinguished in the same manner as *Diel. ficus*.

An European carboniferous shell which by its flat valves, long thin beak, and nearly straight frontal line recalls to a great extent the form of *Diel. itaitubense* is *Diel. hastæforme*, Kon. sp., but this species seems not only never to attain the size of the Indian shell, but is also devoid of the lateral carinations on the beak which are so characteristic of Derby's species.

IV.—Group of *DIELASMA BIPLEX*, Waagen.

7. Dielasma biplex, Waagen, n. sp., Pl. XXV, figs. 3, 4, 5.

This species is somewhat variable in its general outline. It is always more or less distinctly pentagonal, but some specimens are about as long as they are broad, whilst others are much more elongated, and then their pentagonal outline is much less distinctly developed.

On the dorsal side of the shell two strong straight folds start from the apex of the smaller valve, whilst on the ventral side only one mesial fold exists. The frontal line is vaulted, with a sinuation in the middle as in biplicate *Terebratulæ*.

The larger, or ventral, valve is very regularly arched in the longitudinal direction, but it is generally flatter in young specimens than it is in old full-grown ones. In the transverse direction on the contrary its arcuation is rather irregular. In young specimens it is everywhere flatly vaulted, but in old ones it becomes nearly quite flat in the middle of its length. Laterally this valve is rather strongly cut out for the reception of a lobe coming from the dorsal valve. The beak is not long, tolerably thick and distinctly bent over. It is pierced just behind the apex by a tolerably large oval foramen. The deltidium is not very large, but distinctly visible in some specimens. The false area, which adjoins the beak on its lower lateral part, is

tolerably broad, but not distinctly marked off from the remainder of the shell. From the middle of the length of the ventral valve a well developed but not very broad or high obtuse ridge extends towards the frontal line, and is shut in on both sides by low rounded excavations, corresponding to the zigzag bend of the frontal line. The whole frontal part of this valve is distinctly bent up.

The dorsal valve is nearly quite straight, only slightly vaulted longitudinally, but is strongly bent transversely, and generally more so than the ventral valve. This bent condition causes the dorsal valve to form on both sides a kind of lobe or prominence, which fits into a broad sinuation of the margin of the ventral valve. From near the apex there start two strong, perfectly straight rounded folds which get stronger the nearer they approach the frontal line. Between them a deep valley is formed, which commences not far from the apex as a low, flat depression of the shell, and is deepest on the frontal margin. Near the apex, which is rather pointed, the margins of this valve are slightly excavated, and then descend in a broad, prominent arch to the zigzag frontal line.

The internal structure of this shell is not known to me in every detail, but in some of the specimens it can distinctly be seen that strongly developed dental as well as septal plates are present.

The punctation of the shell, which can be very distinctly seen on two of the specimens, is extremely fine but not very close, but, on the whole, much finer than in any of the species described on the foregoing pages.

The measurements of the three figured specimens are as follows :—

	I.	II.	III.
Entire length of the shell	33 mm.	27 mm.	21 mm.
Length of the dorsal valve	30 „	25·5 „	19·5 „
Entire breadth of the shell	21 „	20 „	18 „
Entire thickness „	14 „	11 „	9 „
Apical angle of the larger valve	65°	65°	70°
„ „ „ „ smaller „	100°	103°	105°

The shell is widest about the middle.

Locality and geological position:—There are altogether three specimens of this species in the Salt-range collection. One of them was found by myself at Virgal in the white crinoidal limestone forming the middle division of the Productus-limestone. The two others were collected by a native servant called Mogul and have been communicated to me by Dr. H. Warth. One of them is from Vurcha, preserved in a reddish hard limestone, and comes beyond doubt also from the middle division of the Productus-limestone. The other comes from Musa-kheyl and is silicified. The numerous silicified shells which have made this locality celebrated come out of a bed which must be assigned to the middle division of the Productus-limestone, and it is thus highly probable that also this third specimen was found in that division. From this it is probable that all our specimens of *Diel. biplex* came from the middle division of the Productus-limestone, and that the species is restricted to that division.

Remarks.—This species seems to be somewhat variable chiefly as to its length, breadth and thickness. By the three specimens figured on Pl. XXV these variations are well brought out. Whilst fig. 3 represents a very short and broad, nearly pentagonal variety, which is also rather flat, the other extreme as regards length and thickness is represented in fig. 5. The apical angle is also slightly variable in different varieties. One character however, which can very easily be recognised, and which is highly characteristic for the species, and common to all the varieties, is the presence of strong, straight folds, which start from near the apex of the dorsal valve and reach down to the frontal line. It is by this character that this species can be distinguished from *Diel. problematicum*, (Dav.) W., and the other species which will have to be described hereafter.

Of non-Indian shells there are very few which could be compared to the present one. Of all that are known to me from the carboniferous deposits of Australia, *Rhynchonella inversa*, Kon., is the only one that possibly could be compared to our *Dielasma biplex*. The general arrangement of the plications, the somewhat pentagonal shape, the thick overhanging beak, truncated by an oblique large foramen, all these are points of similarity which cannot be denied. M. de Koninck does not state his reasons for considering this shell as a *Rhynchonella*. The figure, with its thick truncated beak, certainly recalls the form of a shell belonging to the *Terebratulidæ* rather than that of a *Rhynchonella*.

Of *Terebr. bisinuata*, M'Coy, which might possibly resemble the present species, and which also occurs in the carboniferous deposits of Australia, neither figures nor description are accessible to me.

8. DIELASMA PROBLEMATICUM, (Dav.) Waagen, n. sp., Pl. XXVI, figs. 3, 4.

1862. *Terebratula biplicata*, Brocchi (?), var. *problematica*, Davidson: Quart. Jour. Geol. Soc., Lond., Vol. XVIII, p. 26, pl. I, fig. 3.

1863. *Terebratula biplicata*, Brocchi (?), var. *problematica*, (Dav.) Koninck. Foss. Paléoz. de l'Inde, p. 31, pl. IX, fig. 3.

The general outline of this species is somewhat trapezoidal or elongately pentagonal, the greatest breadth of the shell being situated high up, not far from the beak. The shell is very strongly inflated, but the two valves are vaulted in an opposite direction. Whilst the ventral valve is curved longitudinally, the dorsal one is vaulted transversely. The frontal line is biplicate.

The ventral valve is longitudinally very strongly but very regularly vaulted, and it is only slightly more curved in the region of the beak than in the frontal part. In the transverse direction, on the contrary, it is for the greater part of its length, beginning not far from the beak, nearly entirely flat or even slightly excavated, as shown by fig. 3*c* on Pl. XXVI. In all the specimens that have been found up to the present a more or less prominent rounded longitudinal ridge is present on the ventral valve, which generally commences about the middle of the

length of the shell and, growing slowly stronger, reaches down to the frontal line. In some specimens this ridge is limited only to the frontal part, whilst the remainder of the ventral valve is smooth; in others, but very rarely, this ridge commences already on the beak and thus extends over the entire length of the shell. In these latter specimens it is at the same time more strongly developed than in others. In every case this ridge is accompanied on both sides by depressions, more or less deep, which commence where the ridge begins and extend to the frontal line, corresponding there to two projecting parts of the valve, causing the plications of the dorsal valve.

The beak is not very thick, nor prominent, but well bent over. It is obliquely truncated by a tolerably large oval foramen, which pierces the beak just behind its apex. The deltidium is well developed but mostly concealed. On both sides below the beak a broad false area extends; there are, however, just the slightest traces of ridges which would define the false area from the remainder of the shell.

The dorsal valve is very characteristic by its general configuration. It appears very flat when seen in profile, as it bends but very slightly inside in the region of the apex, and is otherwise perfectly straight. The bend of this valve appears, however, perfectly different in a transverse section of the shell, or, if we consider the front view as represented in fig. 3*c* of Pl. XXVI, in which the lateral parts of the shell are strongly depressed, whilst the middle part is strongly elevated; an appearance which is caused by the lateral parts of this valve forming broad, rounded lappets, hanging so far down on both sides of the shell, that, in a profile or side view, the ventral valve is entirely concealed by the dorsal one from about the middle of the length of the shell down to the front.

The dorsal valve is ornamented by two strong folds, separated from each other by a deep groove; they commence about the middle of the length of the valve, but never at the apex, and reach down to the frontal line.

Both valves show a number of striæ of growth, which are, however, never very conspicuous.

Of the interior arrangement of this shell nothing but two very strongly developed dental plates can be seen.

The punctation of the shell is as fine in this species as in the preceding one, but there are many slightly larger pores irregularly disseminated between the smaller ones.

The measurements of three specimens, I and II from Morah, No. III from Musakheyl, are as follows:—

	I.	II.	III.
Entire length of the shell	36mm	29 mm	19 mm
Length of the smaller valve	? 31 „	25 „	17 „
Entire breadth of the shell	24 „	17 „	13 „
„ thickness „	? 19 „	14 „	11 „
Apical angle of the larger valve	77°	75°	68°
„ „ smaller „	?	110°	95°

Locality and geological position.—There are altogether four specimens of this species in the Salt-range collection. Two of them were found by Mr. Wynne at Morah in the middle region of the Productus-limestone; one, the largest, is only a ventral valve and is contained in a very hard white limestone; the other, smaller, comes out of a yellowish, slightly oolitic marly limestone. Another specimen, a fragment of a dorsal valve was collected by myself in the mountains east of Katwáhi in a very hard, compact, white limestone forming the lower part of the middle division of the Productus-limestone in that country. The last specimen was furnished to me by Dr. H. Warth and was collected by his servant Mogul at Musakheyl. The specimen is silicified and was evidently obtained from the particular bed that has yielded so many other fossils from that locality, that is to say out of the upper region of the middle division of the Productus-limestone. The species thus seems to occur in different horizons within the middle Productus-limestone, but seems not to descend into the lower nor to go up into the upper division of the same formation.

Remarks.—This species is most strikingly characterised by its short folds, which never reach the apex of the smaller valve, and by the greatest breadth of the shell being situated not far from the apex, producing an outline as of shoulders, from which the shell tapers more or less regularly towards the frontal line. These are the characters by which this species can most easily be distinguished from other allied forms, such as *Diel. biplex* described above, in which species the folds reach up to the apex of the smaller valve, and the greatest breadth is situated about the middle of the length of the shell.

Terebratula biplicata, Brocchi, with which this shell has been compared by Mr. Davidson, may be similar in its general outline, but the strong dental plates which can easily be stated to exist in every specimen are absent in the cretaceous species, and, thus, there can be but very little doubt that the Indian shell is widely different from Brocchi's species.

9. Dielasma acutangulum, Waagen, n. sp., Pl. XXVI, figs. 1, 2; Pl. XXV, fig. 7.

This very interesting species is characterised by its narrow elongated shape, rather flat valves, and a sharp, slightly biplicate frontal line.

The ventral valve is regularly but not strongly curved in both directions. Longitudinally the curvature is a little stronger on the beak than in the frontal region, and also transversely this valve is more strongly vaulted near the beak than near the front. In the frontal region this valve is produced into two bent-up lappets corresponding to the two folds of the dorsal valve. Between these two lappets, which are slightly depressed, the margin of the valve is cut out correspondingly to a slightly elevated rounded ridge, which extends a little way up the shell. The beak is small and well bent over, pierced just behind its apex by a

rather small roundish foramen. The false area extending on both sides below the beak is tolerably broad, and reaches far down on both sides of the shell. It is limited above by a very indistinct, obtuse ridge, which commences on both sides of the foramen and terminates low down at the lateral parts of the valve.

The dorsal valve is not quite so strongly vaulted as the ventral one. In a longitudinal direction it is very flat, and deviates but little from the straight line. Only near the apex it is somewhat more strongly curved, but in the frontal region it appears sometimes as if impressed, which causes the extreme sharpness of the front. Transversely this valve is much more strongly vaulted than longitudinally, and equals in that respect the curvature of the ventral valve. In the apical region this transverse curvature produces peculiar features in most of the specimens. From both sides of the apex flat triangular spaces descend along the margins of the valve, forming part of the false area, which thus encroaches upon the smaller valve. These flat spaces are divided from the remainder of the valve by very obtuse, barely perceptible ridges.

In the frontal region of this valve there are two more or less strongly developed short folds, which are entirely absent in young specimens, and are even in old ones often so very little expressed that they might easily be overlooked. In other specimens they are more strongly developed, but never more so than in Fig. 1 on Pl. XXVI.

This species is very apt to display the internal characters, as it is generally very completely silicified, and with diluted acid the internal structure is readily exposed. Yet it is not easy to get a complete loop, as most specimens have received slight cracks by pressure, and the loop falls to pieces when the matrix is removed. From all that I have been able to observe, I cannot but doubt that the loop was short and very much like that in *Terebratula*, the crura remarkably straight, attached for a rather long way to the dental sockets, which are long and very strongly developed. At the place where the crura get detached, two long convergent spurs are situated. From there the crura descend quite straight, and are then united by a small curved and tolerably broad cross-piece, without any recurving branches. At the apex there is a rather strongly developed cardinal process. Immediately below this process a broad triangular slit commences, limited on both sides by the attached parts of the crura. Between these one looks down to the bottom of the shell. Here, very near the middle line, the two septal plates take their origin and ascend in an oblique direction to be joined to the bottom of the dental sockets. Between these plates, the sockets and the external shell, a triangular pyramidal hollow space is separated from the remainder of the space of the shell, commencing with its very pointed apex at the cardinal process and reaching down as far as the septal plates extend. These latter are very long in this case, attaining nearly the length of the loop. At the point where the septal plates terminate as low ridges, the impressions of the two anterior adductors are situated rather far apart, separated from each other just by this last extension of the septal plates. Further up, situated partly on the

septal plates and partly on the bottom of the shell the impressions of the two posterior adductors can be observed; they are much smaller than those of the anterior adductors, are very close together, and nearly touching each other in the median line.

In the ventral valve two very strong dental plates are present, but the muscular impressions could not be made out.

The vascular impressions can be seen on a partial cast, in which however the apical region is concealed. Two strong veins are observable in the dorsal valve; these originate apparently on the inner side of the anterior muscular impressions and extend, in a slightly divergent direction, towards the two folds of the valve. They do not seem to ramify much. On the lateral parts of the valve these two principal veins are followed by several others of smaller size, which go in a nearly parallel direction, diverging only very slightly towards the lateral margins of the valve. In the ventral valve one very strong median vein is observable; it commences about where the dental plates disappear and extends for about one-third of the entire length of the shell. Near its lower end, on both sides, a number of smaller veins appear, which are also nearly parallel, and stretch down to near the lower lateral margin of the valve with but slight divergence. In all these veins no distinct ramifications can be observed.

The measurements of two specimens, one from Jabi, the other from Chidru, are as follows :—

	I.	II.
Entire length of the shell	27 mm.	26·5 mm.
Length of the smaller valve	25 „	24·5 „
Entire breadth of the shell	16·5 „	16 „
„ thickness „	10 „	10 „
Apical angle of the larger valve	55°	53°
„ „ of the smaller „	77°	73°

Individuals of this species seem to grow much larger than the specimens of which I have given the measurements. There are some fragments which indicate a shell of at least 38 mm. in length, whilst at the same time their breadth has not been more than 19 mm. and their thickness 16 mm. The region of the beak gets very much inflated in these large specimens, and, in consequence, the apical angle of the larger valve decreases considerably as the shell grows larger, so that in one of the fragments mentioned it is not more than 35°.

Locality and geological position.—Several specimens of this species were collected by myself at Jabi and Chidru, at both localities in the so-called Cephalopoda-bed. At the first locality I found six specimens together with *Cyclolobus oldhami*, W., described on the foregoing pages, whilst at the latter locality four specimens were detected by me in the bed with *Xenodiscus carbonarius*, W. Only one fragment of a large specimen was found by me at Chidru in beds a little above the *Xenodiscus carbonarius* bed. It is thus evident that this species is most characteristic of the Cephalopoda bed of the upper division of the Productus-

limestone, and that it is only very rarely met with in beds a little above the one mentioned.

Remarks.—The most striking feature of this species is the very small apical angle and the very elongated shape the shell attains. The slight development of the frontal folds led me formerly[1] to compare this species to *Diel. elongatum*, Schl. sp., a comparison which cannot stand any longer, as nothing but a generic affinity exists between the two forms.

Of the shells hitherto described only *Diel. problematicum*, (Dav.) Waagen, can be more particularly compared, but this species can easily be distinguished from the one here under consideration by its larger apical angle, less elongated form, and the particular curvature of its dorsal valve. The affinity between the two forms is, however, not so close that it could be affirmed or made to appear probable that the two species are in a developmental connection, though both occur in succeeding strata.

10. Dielasma breviplicatum, Waagen, n. sp., Pl. XXV, figs. 6, 8; Pl. XXX, figs. 11, 12.

The general form of this shell is more or less pentagonal, rather broad in comparison with its length. It is mostly rather flat and provided in the frontal region on the dorsal valve with two short folds.

The ventral valve is very equally arched, sometimes less, sometimes more, but there is no difference between the curvature on the beak or that near the frontal region. Also, in the transverse direction the ventral valve is everywhere well vaulted, never flat or excavated as in *Diel. problematicum*. The raised rounded ridge which ornaments this valve in *Diel. biplex* or *problematicum* is here absent, and only on the frontal region a slight elevation is observable according to the folding back of the biplicate frontal line. The beak is not very large and not much bent over. It seems to be pierced just at its extremity by a not very large round foramen. A distinct small deltidium is present, but it is rarely visible. The false area which extends from both sides of the foramen is tolerably broad, and separated from the remainder of the shell by a very obtuse ridge, which extends from the sides of the foramen to the lateral parts of the valve.

The dorsal valve is longitudinally very little less vaulted than the ventral one. Transversely the curvature of both valves is absolutely equal, only that the lateral parts of the dorsal valve are a little more deflected than the remainder of the shell, and thus hang down a little, thereby recalling, to a certain extent, the shape of the dorsal valve of *Diel. problematicum*. In the frontal region the dorsal valve bears two short folds, which do not extend even up to the middle of the length of the shell but are entirely limited to the frontal region. Nevertheless, they are some-

[1] Mem. Geol. Surv., Ind., Vol. IX, p. 353.

times very strongly developed, and even generally well expressed, only in few specimens are they but slightly indicated.

The internal arrangement in this species could be well studied in some silicified specimens, which were treated with diluted acid; but in this case also the internal parts could only be studied during the process of developing, as on removal of the matrix they immediately fell to pieces owing to numerous minute cracks, by which they were traversed. At the apex of the dorsal valve there is a very distinctly developed cardinal process, at both sides of which the two extremely long dental sockets take their origin. They are formed by a shelly plate, which is fixed to the cardinal margins of the valve and first bends down and then up again, forming a high crest, which limits the dental socket on the inner side, and descends obliquely to the bottom of the valve, being fixed there for its entire length. Joined to these shelly laminæ forming the dental sockets and the septal plates, are the upper parts of the crura, which originate at the cardinal process, and extend across the septal plates, projecting from them as sharp, narrow, prominent margins. The space between these latter is free from shelly matter up to the very cardinal process, and, thus, it can hardly be said that there is a hinge-plate. At the bottom of the valve, which is thus exposed to view, a thickened prominent line is observable, which takes its origin just below the cardinal process, and descends as far as the septal plates extend, following exactly the median line of the dorsal valve. If then the septal plates are very oblique, which is sometimes the case, they are no longer joined to the bottom of the valve, but reach this raised middle line, and then it appears as if a septum were present, and the whole apparatus takes a shape very much like that figured by Davidson (Brit. Perm. Brach., pl. I, figs. 18-20) of *Diel. elongatum*, Schl. sp. At the point where the crura get detached from the septal plates, the oral processes or spurs are situated and converge directed slightly upwards and inwards towards the middle of the shell. They are in no way very large or conspicuous. The crura themselves descend in a remarkably straight manner for more than half the length of the valve, diverging considerably as they extend, so that their lower ends are rather far apart. They terminate in sharp points. Recurving branches do not exist. The cross-piece is not well preserved in any of the specimens I was able to examine. It seemed broad and very little curved, remarkable also by its comparative straightness.

In the ventral valve two very long and very strongly developed dental plates are present. The hinge-teeth are developed as long and high ridges, which extend from both sides of the deltidium along the hinge margin, and are separated from the latter by a deep furrow. They are highest at their lower extremity, and united at their inner side to the dental plates, which ascend vertically to the roof of the valve. These two plates surround the foramen laterally, and then, fastened on the one hand to the roof of the valve, on the other to the hinge-teeth, extend in a divergent direction to about one-third of the entire length of the shell.

The muscular impressions could only be observed in the dorsal valve; in the

ventral one even, with the utmost care, they could not be detected. In the dorsal valve the impressions of the anterior adductors are most conspicuous. They are large, and about the shape of a pointed leaf, the pointed side being turned towards the apex of the valve. The point is situated a little above the lower termination of the septal plates, and from there the impression extends nearly parallel to the middle line of the valve. The impressions of the posterior adductors are much smaller, of an oval shape, and situated between the two pointed extremities of the impressions of the anterior adductors. They are separated from each other by the elevated middle line which I have described above, and from the impressions of the anterior adductors by the ridges which form the last extension of the septal plates.

The punctation of the shell is extremely fine, and the punctures show some tendency to be arranged in radial rows.

The measurements of two middle-sized specimens, No. I, from Chidru, No. II, from Khura, are as follows:—

	I.	II.
Entire length of the shell	25 mm.	24 mm.
Length of the smaller valve	23 „	22 „
Entire breadth of the shell	19 „	16 „
„ thickness „	10 „	11 „
Apical angle of the larger valve	82°	75°
„ „ of the smaller „	110°	102°

Shells of this species attain to much greater dimensions than those of the specimens of which the measurements are here given, but no complete specimen of larger size has yet been obtained.

Locality and geological position.—There are altogether six specimens of this species in the Salt-range collection, and all came from different beds of the upper division of the Productus-limestone; it thus appears that this species, in opposition to that last described, which is limited chiefly to the *Cephalopoda*-bed, is characteristic of the whole upper division of the Productus-limestone, not limited to any particular bed. It was found in this upper division by myself at Khura, (1 specimen), at Chidru (1 specimen), and by Mr. Wynne in the Bazár Wán (1 specimen). Besides these, one specimen was collected by myself in the *Cephalopoda*-beds of Chidru and two specimens in the same bed at Jabi.

Remarks.—This shell is allied chiefly to two of the before described species, *Diel. problematicum* and *Diel. acutangulum*. With both it has the short folds on the frontal part in common, but it can very well be distinguished from the first by the much smaller curvature of its valves, and chiefly by the fact that both valves are about equally vaulted, longitudinally as well as transversely, which is not the case in *Diel. problematicum;* from the second it differs very considerably by its much larger apical angle and comparatively short shape, as well as by some peculiarities of its internal arrangement.

With some varieties of *Diel. biplex*, W., the present species has the short

pentagonal form and flatness of the valves in common, but it can easily be distinguished by the short frontal folds, which in *Diel. biplex* reach up to the apex of the dorsal valve.

There is little doubt but that *Diel. breviplicatum*, W., is developmentally connected with some of the geologically older forms, *Diel. biplex* and *Diel. problematicum*, more probably with the former than with the latter, on account of the similarity in the general curvature of the valves which exists in the first case.

Genus: DIELASMINA, Waagen, n. gen.

Already in the introduction to the subfamily *Terebratulinæ* I have briefly characterised this genus.

From the specimens contained in the Salt-range collection, it appears that the shells belonging to the genus are characterised by a more or less globose form, strong and irregular radial plications, which do not cover the whole shell, but are limited to the marginal parts, and internally by the existence of strong dental and not less strong septal plates.

The materials for this genus available are very small indeed, and thus it has not been possible to develop the loop out of the matrix, or to make sections through the shell in order to ascertain the extension and shape of the loop. Nevertheless, it is nearly certain that the species belonging to this genus possessed a short loop, as do the other shells of the subfamily *Terebratulinæ*.

On the whole this genus occupies a truly transitional place between the genera *Dielasma*, King, and *Hemiptychina*, W. The strong development of dental and septal plates agrees with *Dielasma*, whilst the external shape of the shell is exactly like that of *Hemiptychina*.

The view might be advocated that the shells belonging to this genus ought to be simply included under the genus *Dielasma*, and that the creation of a new genus is superfluous. This view might be reasonable, if the opinion were held that all the shells forming the subfamily *Terebratulinæ* ought to be considered as forming only one genus; but if Douvillé's and other genera be accepted, even only to a certain extent, the creation of this genus can barely be avoided. *Dielasmina* differs from *Dielasma* quite as much as *Pygope*, Link, differs from *Terebratula*, and it is only a consequence of the system that the shells bearing the characters of *Dielasmina* must be considered as constituting a proper genus.

Only one species belonging to this genus is known to me,—this is *Dielasmina plicata*, Waagen,—which occurs in the Salt-range in the uppermost beds of the middle division of the Productus-limestone, and in the upper division of the same formation.

1. Dielasmina plicata, Waagen, n. gen. et sp., Pl. XXVII, fig. 10.

The general form of this shell is more or less globular, with very much inflated valves, strongly plicated at their margins, with a slightly vaulted frontal line and a small but well curved beak.

The ventral valve is very strongly vaulted in both directions, longitudinally as well as transversely. The longitudinal curvature is equal throughout the whole extent of the shell in one specimen, whilst in another specimen it shows a sudden bend not far from the frontal region. The frontal part is a little produced in this valve, so that the frontal line appears slightly vaulted. From the beak to about half the length of the valve the shell is entirely smooth, and even striæ of growth can barely be observed. After this the shell becomes undulating, the undulations being at first very indistinct, and only as the shell expands are distinct radial folds formed, reaching down to the margin of the valve. The number of these folds is somewhat variable, and in this valve it is four to five in the frontal region and two more on each lateral part. The frontal and lateral margins of the valve form a zigzag line. The beak is small, well bent over, obliquely truncated, and distinctly pierced behind its apex by a narrowly oval foramen. A false area can hardly be said to exist, the beak being so perfectly rounded. Slight impressions on each side below the apex replace the false area. The deltidium is concealed in the two specimens I have studied.

The dorsal valve is even more strongly vaulted than the ventral one in both directions, but longitudinally its curvature is very unequal. Beginning from the apex it seems rather flat and straight until having reached about half its length, when it first bends down in a strong curve and then even curves over, so that this curved part of the dorsal valve overhangs the frontal line considerably. Where the valve begins to bend its plication also commences, and stretches thence down to the margins of the valve. There are either three or four folds on the frontal part, and three more on each side of it.

Of the internal arrangement of this species the loop is not known to me, but in both the existing specimens very strong and long dental plates can be observed in the ventral valve. Between these, following the middle line of the valve a thickened shelly line exists, commencing at the margin of the foramen and extending yet a little farther than the dental plates. In the dorsal valve the dark lines in which the septal plates unite with the valve can be very distinctly traced. In the middle line of the valve, beginning at the apex, there is a very strongly marked, prominent, shelly ridge not unlike a septum but much less high, exactly like that described a few pages back in *Diel. breviplicatum*, W.

The substance of the shell is extremely finely punctured.

The measurements of two specimens, No. I from Khura, No. II from west of that village, are as follows:—

	I.	II.
Entire length of the shell	22 mm.	22·5 mm.
Length of the smaller valve	19 „	20 „
Entire breadth of the shell	17·5 „	17 „
„ thickness „	16·5 „	16 „
Apical angle of the larger valve	67°	69°
„ „ of the smaller „	110°	113°

Locality and geological position.—Only two specimens of this species exist in the Salt-range collection, both of which were found by me. One I got in the section at Khura, in thin bedded light coloured limestones forming the upper part of the middle division of the Productus-limestone. The other I found in the section west of that village in yellow marly beds forming the very base of the upper division of the Productus-limestone.

Remarks.—Up to the present no palæozoic shell has been described which could be more particularly compared to the present species. *Terebrat. himalayensis*, Dav., has similarly arranged folds, but is much less inflated, and has no dental plates, as will be shown in the description of that species further on in this work. Of other shells jurassic species chiefly may be compared with *Dielasmina plicata*, and some are, according to their external form, even very similar. Among these are notably *Terebrat. fimbriæformis*, Schaur., or *Terebrat. renierii*, Cat. On close examination of these forms, however, it soon becomes evident that the similarity to *Dielasmina plicata* is only an external one, as the dental plates which characterise the genus *Dielasmina* are absent.

Genus: HEMIPTYCHINA, Waagen, n. gen.

In the introduction to the subfamily *Terebratulinæ*, I have already given a short diagnosis of the genus, and it remains now only to add some words more on the geological distribution of the genus, &c.

The genus is distinguished very characteristically from the greater number of palæozoic *Terebratulæ* by the absence of dental plates in the ventral valve. In this respect it approaches more closely the mesozoic forms, in which dental plates are nearly always absent. The septal plates which the present genus possesses, though more peculiarly characteristic of palæozoic shells, are not restricted to shells from those periods, as species with septal plates still occur commonly in the oldest periods of the mesozoic era.

The loop itself is exactly like that of *Terebratula* proper, and is even less peculiar than, for instance, that of *Dielasm. breviplicatum*, W., described above.

The plication of the shell, though the specific name points to this character, is not absolutely indispensable for the shells belonging to the genus. Not only do young shells generally appear to be smooth, the plication commencing only after

the shell has attained a certain size, but in some cases full-grown shells also are absolutely devoid of plication, though this latter case appears to be only the exception to the rule, plication being generally present.

It is almost certain that the genus existed already during the devonian period; and there is but very little doubt that some of the species of *Terebratula* described by Hall in the fourth volume of his Palæontology of New York belong to this genus. After this, however, there is a great gap, as I know of no species in the mountain-limestone proper that I should like to attribute to the genus. The small group of forms belonging to the genus in the Salt-range appears to be rather isolated, as in more recent strata no similar forms are known to exist up to the lias. The discovery of connecting links between the older devonian shell and the more recent liassic shells must be looked for.

The liassic shells which I have just alluded to appear in the lias of the Alps in grey limestones, which have been considered up to very recent times as belonging to the inferior-oolite according to the numerous and well-preserved plant remains they contain, but which have been shown by Zittel and others to be of liassic age. There are chiefly two species which must be taken into consideration; these are *Ter. rotzoana*, Schaur., and *Ter. renierii*, Cat., or *Ter. fimbriæformis*, Schaur. I had opportunity to study large numbers of these species, thanks to the kindness of Prof. Benecke of Strassburg, who sent me all the stock of these forms contained in the Strassburg Museum for comparison. Though the preservation of these shells is very little favourable to a close examination of the interior characters, yet so much could be made out that these shells very likely belong, in part at least, to the genus *Hemiptychina*. Zittel, in his palæontological manual, expresses the opinion that these forms probably were the precursors of *Waldheimia*, but I could not find a long loop either in *Ter. rotzoana* nor in *Ter. fimbriæformis*, Schaur. In both these forms the loop is not longer than half the length of the dorsal valve, and has no long recurving branches. Nevertheless the two shells differ more or less strongly from each other. *Ter. rotzoana* possesses a strong septum, to which the two short septal plates are fastened, exactly as is the case in *Cœnothyris*. In *Ter. renierii*, Cat., on the contrary, a septum is absent; the septal plates, which are also very short, as in *Hemiptychina*, are fastened to the bottom of the valve, and, as the dental plates in the ventral valve are also absent, there would be no reason for distinguishing this shell generically from *Hemiptychina*, except the development of the cardinal process in the dorsal valve, which is very strong and thick in *Ter. renierii*, whilst it is very small and little developed in all the species of *Hemiptychina*, as far as this part has been studied up to the present. Nevertheless it cannot be doubted that *Ter. renierii* is very nearly related to *Hemiptychina*, and both can be considered as being in a developmental connection. Thus, it is evident that the species of *Hemiptychina* occurring in the Salt-range represent more a mesozoic than a palæozoic type, as in the devonian formation shells probably belonging to *Hemiptychina* are very rare, in the mountain-limestone proper they are

entirely absent, and it is only in the Salt-range and in mesozoic formations of Europe that similar shells attain a greater development.

There is, however, yet another point worthy of consideration in connection with the two Alpine species. *Ter. rotzoana* is, as it seems, probably a *Cœnothyris*, though the shield-like expansion on the transverse piece of the loop has not been observed up to the present (the dental plates in the ventral valve become also in typical forms of *Cœnothyris* obsolete in adult specimens); whilst *Ter. renierii* should very likely be considered as a *Hemiptychina;* nevertheless, there exists a perfect transition of form between the two species, so that it would be possible to figure even more complete transitional series of these two than those that have been figured by Davidson of the different species of *Terebratula* occurring in the carboniferous formation. It must, however, be remarked, that such transitional forms are chiefly numerous at one locality, "Sega di Noviglio" near Rovereto, where *Ter. rotzoana* occurs in very great numbers, whilst *Ter. renierii* is much less numerous, but occurs intermixed with the other species. This occurrence of intermediate forms between the two species, I am now very much inclined to attribute to hybridity, which is so very easily effected in organisms where no special organs for copulation exist, but where the sea-water is the only means of sexual intercourse between the separate individuals. We can also make very similar observations regarding the species of *Hemiptychina* occurring in the Salt-range.

The genus *Hemiptychina* is rather largely represented in the different divisions of the Productus-limestone of the Salt-range, for not only are individuals belonging to the genus rather numerous, but they can also be referred to a number of species.

Five species of *Hemiptychina* are distinguishable among the specimens in the Salt-range collection. One of them has been long known to science, and was described by Davidson as *Terebratula himalayensis*. Two others are very nearly related to Davidson's species, and are chiefly distinguishable by less strongly developed folds. I shall call these two *Hem. sublævis*, W., and *Hem. sparsiplicata*, W. Another species is easily recognisable by its very inflated valves, and will bear the name of *Hem. inflata*, W. The last species presents a great number of folds, and will therefore receive the name of *Hem. crebriplicata*, W.

The geological distribution of these species is unequal. The oldest of them is *Hem. sublævis*, which occurs in the lower division of the Productus-limestone. The lowest beds of the middle division of the same formation are characterised by *Hem. sparsiplicata*, W., whilst in the upper region of the middle division and in the upper division of the Productus-limestone *Hem. himalayensis*, Dav. sp., occurs in great numbers. There are, it cannot be denied, some stragglers of the geologically older species sometimes also in more recent strata, but in general the appearance in time of the species is as I have indicated. The species mentioned are the three principal ones. They form in a very prominent manner a developmental series, which is characterised by the successive apparition of folds on the shell. Round this series the other species can be grouped—*Hem. inflata*, W.,

which is not rare in the upper region of the middle division, and in the upper division of the Productus-limestone, and *Hem. crebriplicata*, W., which is restricted to the middle division of the same formation.

1. HEMIPTYCHINA SUBLÆVIS, Waagen, n. gen. et sp., Pl. XXVII, figs. 1, 2, 3.

The general form of this species is more or less ovoid, with strongly inflated valves, a thick well curved beak, with tolerably large foramen, and a vaulted frontal line, which is slightly indented only at the very margin of the valves, indicating a plication that is a very little more distinctly developed in a few specimens.

The ventral valve is very equally vaulted in both directions. The beak is thick, pierced well behind its apex by a tolerably large round foramen, from which a shallow channel extends down to the apex of the beak. The deltidium is large, excavated and limited on both sides by sharp carinæ of the shell; generally, however, it is concealed by the overhanging part of the beak. The false area which extends on both sides below the beak is very broad, and not at all separated from the remainder of the shell.

The dorsal valve is generally a little less strongly vaulted than the ventral one, but the difference is very small, and applies only to the longitudinal bend, whilst in a transverse direction both valves are equally strongly inflated.

The margins of both valves are very little bent; they descend from the apex of the smaller valve in a slight curve towards the ventral valve, and ascend again in the frontal region to form a slightly vaulted frontal line. The lateral parts of the margins are smooth, but the frontal part is indented, forming more or less distinctly a zig-zag line. These indentations correspond in some specimens with indistinct short folds, which are however limited to the immediate vicinity of the margins themselves. These folds appear oftener on the ventral than on the dorsal valve. Their number is irregular, but there are seldom more than three folds or indentations on the dorsal, and four on the ventral valve. Very often there are only two indentations observable in the dorsal valve, and even these are sometimes so faintly expressed as to disappear almost entirely, and then the shell shows quite smooth margins of the valves all round, and only a slightly vaulted frontal line.

Of the internal character of this species nothing could be ascertained, except that in the ventral valve dental plates have not been observed up to the present, but that in the dorsal valve well developed septal plates exist, as is shown by a partial cast from Pail.

The substance of the shell is granulated, but this granulation is so extremely fine that it can only be seen with a magnifying power of 15 to 20 linear, whilst in other *Terebratulidæ* a power of 5 or 6 is sufficient to bring out the puncturing quite distinctly. The punctures are extremely close together, but do not show any kind of regular arrangement.

The measurements of two specimens from Amb are as follows:—

	I.	II.
Entire length of the shell	20 mm.	19 mm.
Length of the dorsal valve	17 „	16 „
Entire breadth of the shell	14 „	14 „
„ thickness „	10 „	11 „
Apical angle of the larger valve	66°	70°
„ „ of the smaller „	101°	104°

The size indicated above is not the largest the species can attain, as a specimen from Pail attains a length of 23 mm.

Locality and geological position.—This species of the genus *Hemiptychina* is the prevailing one in the lower division of the Productus-limestone. Most of the specimens were collected by myself at Amb at two different horizons. Three of them were found by me in the lowest fossiliferous bed there, and ten more in the dark coloured sandstone called by me (in my note-book) "Chonetes-bed," which also belongs to the lower region of the lower division of the Productus-limestone. Three more specimens were collected by me at Pail in those rusty coloured sandy limestones, which have furnished so many Fusulinæ and Spirifers, which will be described later on in this work; these also form part of the lower division of the Productus-limestone.

In higher beds specimens very similar to the present species are sometimes met with, which should possibly be considered as belonging to it, as, for instance, in the lowest beds of the compact Productus-limestone of Katta; but they are all more inflated and show also on the lateral margins of their valves some indentations, and thus prove themselves to be truly intermediate forms between the present and the following species, in either of which they might be placed with equal right.

Remarks.—The peculiarities which characterise this species in particular, and which distinguish it well from other allied forms, consist in the small number of indentations of the margins of the valves, which are generally exclusively limited to the frontal part of the shell, and only exceptionally correspond to short folds near the margins of the valves. In *Hemiptychina himalayensis*, Dav., which is the most nearly related one of all the species hitherto described, the marginal folds are, according to Davidson's description, four or five in the frontal, and two or three more on each lateral part of the shell, and reach for the length of several millimeters up from the margins of the valve.

The specimens of *Hem. sublævis* in which the indentations have been quite obliterated, and smooth margins of the valves thus produced, are not at all dissimilar to some of the species of *Terebratula* described by Hall out of the devonian strata of New-York, and I therefore consider it highly probable that the genus *Hemiptychina* is represented already in the devonian period.

2. Hemiptychina sparsiplicata, Waagen, n. gen. et sp., Pl. XXVII, figs. 4, 5, 6.

The general outline of this shell is shortly ovoid, with tolerably strongly inflated valves, small beak, and almost unvaulted frontline, which is composed of many zigzag bends. The valves are smooth until a short distance from the margin, where coarse plications appear, corresponding with the zigzag bends of the frontline.

The ventral valve is very equally vaulted in every direction. The beak is well bent over, not very thick, and pierced just behind its apex by a not very large round foramen. The triangular deltidium is well developed, excavated, but mostly concealed. The false area is tolerably, but not very, broad, very indistinct and not separated from the remainder of the shell. The valve is entirely smooth for about two-thirds of its length, and then a few coarse but not very prominent folds appear. There are generally two of them in the frontal region and two to three on each lateral part; the two median ones are a very little more prominent than the lateral folds. These folds reach down to the margins of the valve and cause there very strong indentations, which are never, as is mostly the case in the preceding species, limited to the frontal part, but always extend on to the lateral margins.

The dorsal valve is always as strongly vaulted as the ventral one, and its transverse curve is only very little stronger than the longitudinal one. In this valve the marginal plications begin to appear much later than in the ventral one, and about three-quarters of the entire length are entirely smooth, only showing some inconspicuous striæ of growth. With the last quarter of the longitudinal extension of this valve, distant folds begin to appear, which rapidly increase in size and height as they approach the margin. The folds are situated at the interstices between the folds of the ventral valve, causing strong indentations at the valve's margin. There are in the dorsal valve three such folds in the frontal region, and two to three on each lateral part of the valve in full-grown specimens, whilst in smaller ones only one lateral fold is yet developed.

Of the internal characters of this species nothing could be observed, except that there exist no dental plates in the ventral valve. The granulation of the shell is, if possible, even yet finer and closer than in the preceding species.

The dimensions of three specimens from Katta are as follows:—

	I.	II.	III.
Entire length of the shell	18 mm.	17·5 mm.	16 mm.
Length of the smaller valve	16 „	15 „	14 „
Entire breadth of the shell	14·5 „	14 „	12 „
„ thickness „	10 „	10 „	8·5 „
Apical angle of the larger valve	73°	76°	69°
„ „ of the smaller „	120°	123°	111°

Locality and geological position.—This species is not rare at certain localities of the Salt-range, but it appears that its more numerous occurrence is restricted to certain beds, which are very limited in their vertical extent, and always compose the lowest part of the middle division of the Productus-limestone.

The geologically oldest specimen of this species I collected at Amb together with many specimens of *Hem. sublævis*, W., in the so-called *Chonetes*-bed of the lower division of the Productus-limestone.

More numerous specimens are met with, as soon as one enters the lowest beds of the compact limestones forming the middle division of the Productus-limestone. In this position I collected the species at Katta in a yellow marly limestone which I designated in my note-book as bed No. 12, and not less than 15 specimens of this species were collected by me in a few minutes. Three not very characteristic specimens, showing to some extent a transitional form between the present species and *Hem. sublævis*, W., were collected by me in a similar geological position, but probably somewhat lower down, at Nursingpahár, in a black sandy limestone, together with *Dielasma truncatum*, W. Another specimen I found at Amb, also in the lowest beds of the compact Productus-limestone.

There are in the Salt-range collection yet several more specimens of this species, which were collected by Dr. Oldham, and ten of which come from Swás, whilst others are from the Bazár Wán.

The species continues in some straggling specimens up into the upper beds of the middle division of the Productus-limestone, and possibly even sometimes into the upper division, but in these beds it is mostly replaced by *Hem. himalayensis*, Dav. sp. I collected the species in the upper region of the compact limestones at Katta where I obtained two specimens and one at Musakheyl.

Remarks.—This species is chiefly characterised by its large apical angle and its thus more or less roundish form, by its coarse and not numerous marginal folds, and its comparatively small beak. It shows, however, much variation in form and sculpture; and thus many transitions in shape to *Hem. sublævis*, as well as to *Hem. himalayensis*, Dav., can be pointed out. Nevertheless, I thought it expedient to note the typical form by a special name, as it is very characteristic for certain beds; even if there were nothing but a number of *Hemiptychina*, one could tell, by noting the prevailing form among them, what beds they might come from, as, for instance, if the present species were found prevailing one might be sure that these shells came out of the lower region of the middle division of the Productus-limestone.

The characteristic features of this species given above are sufficient to distinguish it from the allied forms *Hem. sublævis*, W., and *Hem. himalayensis*, Dav. sp.

3. HEMIPTYCHINA HIMALAYENSIS, Davidson, sp., Pl. XXVI, figs. 6, 7, 8, 9, 10.

1962. *Terebratula himalayensis*, Davidson : Quart. Jour. Geol. Soc., Lond., Vol. XVIII, p. 27, pl. II, fig. 1.
1863. *Terebratula himalayensis*, (Dav.) Koninck : Fossiles Paléozoiques de l'Inde, p. 32, pl. IX, fig. 1.
1878. *Terebratula himalayensis*, (Dav.) Waagen : Rec. Geol. Surv. Ind., Vol. XI, p. 186.

The general outline of this shell is very variable, roundish ovoid, or elongated, with sharp margins, or, which is oftener the case, truncated at the front. At the margin there are twelve to fourteen short distinct folds; the frontline is on the whole nearly straight, the margin of the valves being, however, frequently indented strongly and frequently according to the folds. The beak is small and pierced just behind its apex by a not very large, sometimes round, sometimes oval foramen.

The ventral valve is generally not very strongly vaulted, and extends sometimes with a very equal curve from the beak to the frontline; but more often it is suddenly deflected not far from the margin and turned with a strong bend upwards. By this peculiarity the ventral valve appears much deeper and much more strongly inflated than it would be otherwise. The beak is well bent over; the foramen is just behind the very pointed apex, and mostly of a roundish form, with a canal extending from the lower margin of the foramen to the apex of the beaks. The deltidium is well developed, excavated for the reception of the apex of the smaller valve, but it is, for the most part, concealed by the overhanging part of the beak. The false area is generally not large and never marked off from the remainder of the shell by any kind of ridge or the like. This valve remains smooth for at least more than two-thirds of its entire length, and only then the plications appear. It is not quite easy to tell which of these plications belong to the frontal region, properly speaking, and which are on the lateral parts, as there exists no proper limit to the frontal part. One can, however, in general, say that there are on this valve at least five folds in the frontal region, whilst there are at least three more of them on each lateral part, so that, on the whole, there are eleven to twelve folds on this valve. When the shell suddenly turns up producing a truncation of the frontal region, this truncated part is covered with many regular, slightly imbricating striæ of growth.

The dorsal valve is as much vaulted as the ventral one. The bend is in some cases quite regular, as in the specimen figured by Davidson; more frequently, however, the valve suddenly turns down vertically or even bends inside to meet the margin of the ventral valve. Generally this truncated part of the dorsal valve is smaller, less high, than that of the ventral one. The dorsal valve remains smooth for a longer distance than the ventral one, that is to say the plications appear later in the dorsal than in the ventral valve, and are therefore in the former more limited to the vicinity of the margins. There are in this valve four to five folds in the frontal region, and three more on each lateral part. In this valve also the truncated part of the shell is covered by many slightly imbricating striæ of growth which form a zigzag line, as does the margin of the valve itself.

The internal characters of this species were very completely ascertained, but it was impossible to distinguish the muscular impressions in the ventral valve.

In the ventral valve the beak is perfectly hollow, without any partitions. At the foramen the margin of the shell is curved, so that the foramen is surrounded on its inner side by a tolerably high, sharp, shelly ring. At both sides of the deltidium the teeth begin as low ridges which extend on both sides along the hinge margins, increasing at the same time in height, and terminating with a prominent but not very high point. They are separated from the hinge-margin by a distinct furrow.

In the dorsal valve there is no very distinct cardinal process on the apex of the valve. The so-called hinge-plate is slit open in the middle up to the very apex; the middle parts, beginning from the dental sockets, are deflected and bent down, and are fixed as septal plates to the bottom of the valve. The dental sockets are on their inner side limited by high, sharp crests, which form one plane with the septal plates. These latter are cut out immediately below the dental sockets, but then again stretch far down the valve as low ridges, separating the muscular impressions. The crura take their origin just below where the dental sockets terminate as broad laminæ, which get rapidly narrower, being narrowest at about one millimeter from their origin. Where the crura are narrowest, broad triangular spurs originate, which are bent somewhat inward towards the middle of the shell. From the spur the crura gradually taper again in breadth, and terminate after having reached a length about equal to that of the dental sockets. The transverse piece of the loop is attached at an acute angle to the crura; it is very narrow and well bent up towards the apex of the valve.

The muscular impression of the dorsal valve can be well seen. The anterior adductors have left large marks near and below the termination of the septal plates. They are of ovoid shape, pointed on the upper and broadly rounded on the lower side, and are placed obliquely so as to touch, in their lower part, nearly the middle line of the valve, whilst their pointed upper part is directed towards the lateral parts of the hinge-margin. The impressions of the posterior adductors are situated between and above those of the anterior ones, separated from the upper part of the latter by the last termination of the septal plates. They are enclosed between the septal plates, are very narrow and very elongated, reaching up to about the lower end of the dental sockets and are separated from each other by a raised middle line of the valve. Though the cardinal process is not strongly developed, yet the impressions of the cardinal muscles can be very well distinguished on it.

The substance of the shell is as finely granulated as that of the preceding two species.

The dimensions of three different varieties of this species, No. I from Swás No. II from Musakheyl, and No. III from Khura, are as follows:—

	I.	II.	III.
Entire length of the shell	20 mm.	21 mm.	19·5 mm.
Length of the smaller valve	18 „	18·5 „	16 „

	I.	II.	III.
Entire breadth of the shell	16 mm.	14·5 mm.	17 mm.
„ thickness „	11·5 „	13 „	8 „
Apical angle of the ventral valve	75°	67°	7.°
„ „ „ dorsal „	115°	110°	120°

The variety No. III is that figured by Davidson, only that his specimen was somewhat large, and measured as much as 23mm. in length.

Locality and geolcgical position.—This species is very common in the Salt-range, though it is so only in certain beds. It begins already in the lower division of the Productus-limestone, and was collected by me in this position in the "*Chonetes*-bed" near Amb, but I only got two specimens. In the lower part of the middle division of the Productus-limestone it also occurs, but is very rare. A single specimen, found by me at Katta in these beds, proves its existence there. The species attains chief development in the upper part of the middle division of the Productus-limestone, and most of the specimens that are preserved in the Salt-range collection come from these beds. I collected seventeen specimens of this species in these beds in the mountains east of Katwáhi in hard light-coloured limestone (silicified), five specimens at Katta in light-coloured silicious limestones, one at Khura in the section there in the topmost beds of the compact limestones, three on the road from Vurcha to Uchâli in light-coloured limestones, and two at Chidru in the top beds of the middle division of the Productus-limestone. This species has been collected by Dr. Oldham in hard light-coloured limestones at Swás (four specimens), at Morah (one specimen), and at Musakheyl (seven silicified specimens). Mr. Wynne obtained one specimen from these beds at Vurcha.

In the trans-Indus continuation of the Salt-range the species was detected in the same geological position by Mr. Wynne at Kálabágh in a grey limestone (three specimens silicified), and at Kafirkót by myself in a light-coloured silicious limestone (two specimens).

There are thus altogether in the Salt-range collection forty-seven specimens out of the upper region of the middle division of the Productus-limestone.

In the upper division of the Productus-limestone this species was found by myself at Jabi in the Cephalopoda-bed together with *Cyclolob. oldhami*, W. (four specimens silicified) ; at Chidru in the Cephalopoda-bed (five specimens), and in the beds above it (six specimens) by Mr. Wynne. This species was also found in this division at Khund Ghat, where Mr. Wynne obtained four specimens.

Remarks.—This species, as I had already occasion several times to remark in the description of it, is very variable in nearly all its characters, and it might thus appear inconsequent on my part were I to leave all these varieties under one specific designation. The truncated varieties, for instance, might well be considered as being different from the broad, flat, typical form as figured by Davidson ; and also the more cylindrical shapes might be something different from the broadly rounded ones ; but the specimens I have at present at my disposal are not sufficient to

settle these points satisfactorily. At present all these different forms seem to be linked together by such an overwhelming number of transitional forms that a further distinction seems at present absolutely impracticable.

The only character by which the species can always be recognised is the number of folds it possesses. By this character alone it is possible to distinguish it from the two previously described species. If one did not seize upon this character it would not be possible to separate even those two species from the present one. I cannot say why greater stress should be put on this character than on others; but the fact is that, in observing the number and development of the plications occurring on these shells, it is possible to tell very positively what horizon a number of *Hemiptychinæ* collected in the Salt-range may have come from. Among a set of shells coming from the lower division of the Productus-limestone, there might be one or two specimens of the form of *Hem. himalayensis*, Dav., but the majority of specimens will always bear the characters of *Hem. sublævis*, W. If, on the other hand, such a set of shells comes from the lower region of the middle division of the Productus-limestone, by far the majority of the forms will always exhibit the characters of *Hem. sparsiplicata*, W., though one or more specimens of the other two species may be among the lot. In the upper region of the middle division, and in the upper division of the Productus-limestones, the forms with numerous folds so far exceed in number the other two forms that the occurrence of the latter becomes quite unimportant.

This mode of occurrence is certainly worthy of notice and cannot be passed over in silence. It is most certain to be taken note of, if the three forms are distinguished as three distinct species, a mode of proceeding which I have adopted here.

Hemipt. himalayensis, Dav., sp., is not restricted to the Salt-range, but occurs also in the Himalaya, where it was collected by Mr. Hughes on the Milam Pass in a white compact limestone. In mentioning the occurrence of this species in the Rec. Geol. Surv. of India, Vol. XI, p. 186, I compared the bed in which the species there occurs to the " lower carboniferous limestone of the Salt-range." This I must correct now to a certain extent, as, at the time I wrote that note, I thought that the Productus-limestone of the Salt-range should properly be divided into only two divisions, to the lower of which the beds in Hundes would possibly have been parallel. Now, however, I can say more positively that it is very likely the middle division of the Productus-limestone with which the Hundes beds may be compared. I am led to accept this opinion not only by the occurrence of *Hem. himalayensis*, but also by the presence of such species as *Ter. subvesicularis*, Dav., and by the fossil which I mentioned under the name of *Bactrynium* sp., and which will be described more accurately further on in this volume. All these forms are more or less characteristic of the compact limestones of the middle division of the Productus-limestone.

4. HEMIPTYCHINA INFLATA, Waagen, n. gen. et sp., Pl. XXVII, figs. 7, 8, 9.

The general form of this shell is more or less globular with extremely inflated valves, a not very large beak, and numerous and strong plications which cover about half the length of both valves.

The ventral valve is very differently curved according to the age and the inflation of the specimen. In moderately sized and not too strongly inflated specimens, the ventral valve is longitudinally and transversely very equally curved, forming in both directions nearly a semi-circle. In somewhat large and yet more strongly inflated specimens, however, the curve is only regular for about half the length of the valve, then a rather sudden deflection takes place, and the shell ascends more or less flatly to the frontal line. The beak is comparatively small, distinctly bent over, and pierced behind its apex by a not very large foramen. The false area is very oblique, not very broad, and not marked off from the remainder of the shell. The greater part of the ventral valve is covered by a strong radial plication, which commences not far from the beak and extends down to the frontal line. In other specimens, half the length of the ventral valve is smooth and the other half plicated. There are four to six folds in the frontal region, and generally three more on each lateral part. The folds are mostly simple, but sometimes one or the other is split up into two already from the beginning or, which is however very rarely the case, all the folds become bifid not far from the frontal line. The margin of the valve, forming a zigzag line, is generally not much produced in the frontal region, and accords with the slightly vaulted frontal line. The valve is ornamented by some conspicuous striæ of growth, which are chiefly crowded together near the margin of the valve.

The dorsal valve is never so equally curved as the ventral one. In the longitudinal direction this valve is nearly flat for about half its length, then a more or less sudden deflection takes place, after which the valve descends either in a slightly broken or rounded curve to the frontal line, or the deflection is so strong, chiefly in the case of large and very strongly inflated specimens, that the shell bends over inward, and the valve then appears slightly shorter at the frontal line than at the place where it makes the bend. Also transversely this valve is not quite equally vaulted. In the apical region the lateral parts are slightly impressed, whilst further on towards the frontal part the transverse curvature gets more regular, until, in very strongly inflated specimens, the lateral parts also turn abruptly down to the margin of the valve. The plications begin in this valve later than in the ventral one, and at least half or more than half of the entire length of the valve is smooth. There are four to five folds on the frontal part of the valve, and four or five more on each lateral part. The margin of the valve is strongly indented where the folds reach it. There are many striæ of growth crowded together along the margin.

Of the internal characters of the species, the loop could not be made visible; it could, however, be clearly ascertained that in the dorsal valve two very strong and very long septal plates existed, which approached each other very much, and extended from the apex of the valve to about one-third of the length of it in a nearly parallel direction, measuring 7 mm. in a specimen of 19 mm. total length, and being at their lower extremity 1·5 mm. apart from each other. In the ventral valve dental plates do not generally exist; there is one specimen, however, in one side of which a faint trace of a dental plate can be traced for some length, whilst on the other side not a trace of such a plate can be detected. (This is probably a case of hybridity with *Dielasmina plicata*, W.)

The granulation of the shell is as fine as in the other species of *Hemiptychina*, and requires a very strong magnifying power to be at all detected.

The measurements of four specimens, Nos. I, III and IV from Morah, and No. II from Khura, are as follows:—

	I.	II.	III.	IV.
Entire length of the shell . . .	26 mm.	24 mm.	22 mm.	19 mm.
Length of the smaller valve . .	21 „	20 „	18·5 „	16 „
Entire breadth of the shell . . .	20 „	18 „	17 „	15·5 „
„ thickness „ . . .	21 „	18 „	16·5 „	14 „
Apical angle of the larger valve . .	71°	65°	72°	72°
„ „ „ „ smaller „ . .	124°	118°	118°	112°

The specimen No. I is the largest and most inflated one known to me.

Locality and geological position.—The greatest number of specimens of this species were collected by Mr. Wynne at Morah in a light-coloured, compact limestone, forming beyond doubt part of the middle division of the Productus-limestone. There are not less than seventeen specimens from that locality. Another specimen was found, also by Mr. Wynne, at Musakheyl, in a reddish, compact limestone. By myself the species was found in the section near Khura in the top beds of the middle division of the Productus-limestone (two specimens), west of Khura in yellow, marly beds at the very base of the upper division of the Productus-limestone (one specimen), and in the mountains east of Katwáhi in white limestones, low down in the middle division of the same formation (three small specimens).

Remarks.—This species shows but small variations, and even young specimens of it can easily be distinguished from *Hem. himalayensis*, Dav., by the very inflated condition of its valves and by its plications, which commence on the ventral valve, not far from the beak. Another species which is rather similar to the present one is *Dielasmina plicata*, W. This can be distinguished from *Hem. inflata*, W., by its less numerous plications, and the very distinct dental plates, which can generally be made easily visible. I have already mentioned above that in one specimen of the present species rudimentary dental plates, or at least one such plate, occurs. I am inclined to consider this anomaly as the result of hybridity between *Dielasmina*

plicata and *Hemiptychina inflata*, as both species are contemporaneous and occur in the same beds.

Among the species occurring in Europe *Hemiptychina renierii*, Cat., from liassic beds of the Alps, can preferably be compared with the species under consideration. I have already stated above the reasons why this species would be considered as a *Hemiptychina*. From our *Hem. inflata* it can be distinguished by its much heavier shell, thicker and less curved beak, with its very large foramen, by the more circular shape and less strongly inflated valves.

5. HEMIPTYCHINA CREBRIPLICATA, Waagen, n. gen. et sp., Pl. XXVII, fig. 11.

The general outline of this species is roundish ovoid, not much longer than it is broad, with slightly inflated valves, a straight indented frontline and tolerably small beak.

The ventral valve is not strongly, but very equally, vaulted in every direction. The beak is not very thick, well bent over, and pierced just behind its apex by a not very long, round foramen. The false area is rather narrow and not marked off from the remainder of the shell. The valve is smooth for a little more than half its length, then a number of folds begin to appear, which soon become very distinct and reach down to the margin of the valve. There are seven folds in the frontal region, of which the middle one is distinctly stronger than the others. On each lateral part there are five folds more, so that this valve bears altogether not less than seventeen folds, of which the two last lateral ones are however rather indistinct. The margin of the valve is finely indented, where the folds reach it. Striæ of growth cannot be detected on the valve.

The dorsal valve is not as equally vaulted as the ventral one. In the longitudinal direction it is tolerably flat for about two-thirds of its length, but from there it bends more rapidly down to the margin. Transversely the curve is rather regular. The flat part of the valve is perfectly smooth, and it is only where the shell bends down that the plication begins to appear. There are six folds in the frontal region, separated from each other by furrows, which are about as broad as the folds themselves. Only the middle furrow is broader and deeper, corresponding to the more prominent median fold on the ventral valve. On the lateral parts there are six folds on each side, so that the valve altogether bears eighteen folds, of which however the two last lateral ones are rather indistinct. Striæ of growth are absent.

The granulation of the shell is as fine as in the other species of *Hemiptychina*.

Of internal characters only the existence of two strongly developed septal plates can be observed. The plates are tolerably long and rather far apart from each other. In a specimen 21 mm. in length they are 6 mm. long, and at their lower extremity 3 mm. apart. In the ventral valve dental plates are decidedly absent.

The measurements of a specimen from Morah are as follows :—

Entire length of the shell	20	mm.
Length of the smaller valve	18	„
Entire breadth of the shell	17	„
„ thickness „ „	11	„
Apical angle of the larger valve	80°	
„ „ „ „ smaller „	115°	

Locality and geological position.—There are altogether three specimens of this species preserved in the Salt-range collection, which were all found by Mr. Wynne. Two of them are from Morah out of white limestones forming part of the middle division of the Productus-limestone; the third specimen is from Kálabágh hill on the western shore of the river Indus, out of marly calcareous beds, also belonging to the middle division of the Productus-limestone.

Remarks.—This species is more or less nearly related to most of the species of *Hemiptychina* described on the foregoing pages, but it can easily be distinguished from all of them by its less inflated valves and by the far finer plication of its shell. There has been, as far as I am aware of, no shell described from any not Indian locality which would compare more particularly with the present species.

Subfamily: *CENTRONELLINÆ* (?)

GENUS: NOTOTHYRIS, Waagen, n. gen.

In the introduction to the family *Terebratulidæ* I have already mentioned the existence of a genus in the Salt-range, which probably could be considered as belonging to the subfamily *Centronellinæ*.

According to the divisions of the *Terebratulidæ* introduced by Von Buch and Quensted the species belonging to this genus would have to be considered as forming part of the *Antiplicatæ*, as there is mostly a considerable sinus in the dorsal valve and a corresponding vault in the frontal line of the ventral valve, so that the general curvature of the frontal line is in an opposite sense to that prevailing in the *biplicate Terebratulæ*. The internal characters of these shells are, however, much more strange than their external shape.

In the ventral valve the hinge is composed of two strong, short teeth, which are rather far distant from the deltidium. The space between the latter and the teeth is occupied by the sharp hinge margin. The deltidium is generally not large but distinct, but whether it was composed of two pieces or not is uncertain. The beak is thick and strongly bent over, but not very long, pierced by a large oval foramen. At the margin of the foramen the shell bends inward and surrounds it on the inner side by a distinct, sharp and high shelly ridge. Dental plates are entirely absent. The muscular and other impressions cannot be distinguished in the ventral valve.

In the dorsal valve the apex bears no distinct cardinal process. From both sides of the apex high, sharp ridges start, which are separated from the hinge margin by a furrow which widens near the extremity of the ridges into a roundish groove for

the reception of the teeth of the ventral valve. Between these two ridges, at their base, a perfectly level, shelly plate extends down to the end of the sockets, filling the triangular space between the apex and the extremities of the two ridges. At the place where this plate is joined to the sloping inner walls of the ridges mentioned above a shallow furrow extends. The most remarkable feature, however, is, that this plate is pierced just in front of the apex by a tolerably large, elongately oval, or slightly triangular foramen. At its lower extremity the plate is limited by a straight, slightly thickened and somewhat raised margin. The crura are fastened to the underside of this plate, at the place which is marked on the upper side by furrows, and where this hinge plate is joined to the socket walls. The crura begin already at the apex and extend on the underside of the hinge plate as divergent, not very far projecting sharp ridges, which never reach down to the bottom of the valve to form what in other genera I called septal plates. Where the hinge plate terminates with its thickened margin, the crura make their appearance from under it, and quickly extend into broad, shelly lamellæ, bearing on their upper margins a high sharp spur. The spurs of both crura are rather far distant from each other. The crura are very strongly curved in the horizontal plane of the valve, but not in a vertical direction. In front of the spurs they get again narrow and extend down more than half (0·6) of the entire length of the valve. Though I took very great pains, and sacrificed nearly a dozen specimens belonging to this genus, I never was able to detect a transverse shelly band connecting the two lower extremities of the crura, and I am almost inclined to think that the loop was not complete, that is to say, that it was only partly calcified.

The impressions of the muscles are also very strange, though very imperfectly known to me. In the ventral valve nothing at all could be seen, but in the dorsal valve there are two very large adductor impressions at the sides of a slightly raised, somewhat broadened and flattened median line, and separated from the latter by small sharp lines. They are of a broadly oval form, but seem to be single, as up to the present not a trace of a second pair of adductors could be detected.

This is all that I could ascertain of the interior characters of this genus. There is no doubt that shells bearing so strange internal appendages should be considered as forming a separate genus, distinct from *Terebratula* and the other genera that have been described up to the present; but it is extremely difficult to find out the relations in which this genus stands to the other *Terebratulidæ*. That the genus forms part of the large family *Terebratulidæ* is demonstrated as well by the absence of spirally coiled appendages, as by the structure of the shell, which is very distinctly, though very minutely punctate. Its punctation is about as minute as in *Hemiptychina* (see *ante*). But beyond this no certainty whatever exists. The peculiarity of an internal foramen in the dorsal valve is, as far as I know, only repeated in a certain group of species of *Athyris*, or even in all the forms belonging to that genus, but beyond this there exists no analogy between *Athyris* and the present genus. I have thought it expedient to bring *Notothyris* into a certain relation to *Centronella*, as possibly belonging to the same subfamily, though I have

not any imperative reasons for doing so. In *Centronella*, as well as in *Notothyris*, the middle part of the frontline is depressed, whereby the two genera have to be considered as belonging to the *Antiplicatæ*. The transverse piece of the loop of *Notothyris* is unknown up to the present, and it is not impossible that this part of the loop was never calcified, but was replaced by soft fleshy parts. The curvature of the crura, as far as they have been observed, is similar in both genera. In *Centronella* also the loop is perfectly free and no septal plates exist, and the cardinal process is as little developed as it is in *Notothyris*. These are at least some analogies, and, as the present genus shows even fewer analogies with the other groups of *Terebratulidæ*, it will be best to place it in a provisional way into the subfamily *Centronellinæ*.

The genus has, as far as is known up to the present, a purely eastern distribution, and is found most numerously in the palæozoic deposits of India, where it occurs in tolerably large numbers in the Salt-range, and, more rarely, in the Himalayas. One species has been described by Abich also from Djulfa on the Araxes.

In the Productus-limestone of the Salt-range there are not less than seven species, which range through the middle and upper divisions of the formation. The geologically oldest species was found by myself at Katta in the lowest beds of the compact Productus-limestone. It is a very small species and will receive the name of *Notothyris simplex*, W. In the middle and upper region of the middle division no less than six species have been met with. They are *Notothyris multiplicata*, W., *Not. minuta*, W., *Not. djoulfensis*, Abich sp., *Not. subvesicularis*, Dav. sp., *Not. inflata*, W., and *Not. warthi*, W. The latter species also ranges up into the upper division of the Productus-limestone, and is there the only representant of the genus, excepting some few specimens of *Not. subvesicularis*, and *Not. lenticularis*, W., which will also be described later on.

The occurrence of *Not. djoulfensis* in the Salt-range is of some interest. The identification of the Salt-range specimens with the Armenian species, will, I think, be found correct, though the figures given on Pl. XXVIII do not look quite as if they were identical with Abich's figure; but there are specimens in the Salt-range which on the one hand cannot be distinguished from Abich's figure, and on the other hand belong unquestionably to the same species as those specimens figured by me on Pl. XXVIII. The interior of the original specimens of *Ter. djoulfensis* is not known, and it is only by the analogy of the external form, and the ascertained internal characters of the Salt-range specimens that I place this form in the genus *Notothyris*. *Not. djoulfensis* is derived from beds which have been ascertained by Prof. v. Möller to be of lower permian age.

Though all the species of this genus which have been found in the Salt-range occur more or less in successive strata, yet no distinct law of development can be made out among them. It is true that the geologically older species are mostly smaller in size than the more recent ones, though none of these species attain considerable dimensions, but at the same time small and larger species appear promiscuously in the fossiliferous beds of Musakheyl, belonging to the upper region of the middle division of the Productus-limestone.

1. Notothyris subvesicularis, Davidson, sp., Pl. XXVIII, figs. 3, 4.

1862. *Terebratula subvesicularis*, Davidson: Quart, Jour. Geol. Soc. Lond., Vol. XVIII, p. 27, pl. II, fig. 4.
1863. *Terebratula subvesicularis*, (Dav.) Koninck: Foss. Paléoz. de l'Inde, p. 32, pl. IX, fig. 4.

The general outline of this shell is broadly oval or slightly pentagonal, with, as a rule, moderately inflated valves, a small beak and only one median fold in the sinus of the smaller valve.

The ventral valve is slightly more strongly vaulted than the dorsal one. Its curvature is very equal, longitudinally as well as transversely. The beak is rather thin, short, not prominent, pierced at its apex or just behind it by a small round or slightly triangular foramen. Below these extends a small triangular deltidium, which is mostly visible, as the beak is not firmly adpressed to the apex of the smaller valve. The margins of the ventral valve are smooth for a certain distance from both sides of the deltidium, but then they begin to be cut out into a zigzag line having two to three indentations on each lateral part. In the frontal part a very distinct sinuation of the margin of this valve takes place, which forms a W-shaped line. The valve is smooth for about half its extent, beginning from the beak, and then strong folds appear which are not sharp but well rounded, and reach down to the margin of the shell. There are altogether six to eight folds, of which two, the two strongest ones, are on the frontal, and two to three on each lateral part.

The dorsal valve is not quite so strongly vaulted as the ventral one, and its curvature is generally not quite equal. It is somewhat flattened in the apical region, and then bends down more suddenly to the margin where the folds appear. For nearly two-thirds of its whole length, beginning from the apex, it is smooth, and only in the last third of its whole extent do strong, short folds make their appearance and reach down to the margin. The latter is produced in the frontal region, forming a tolerably broad W-shaped process. There are generally altogether five to seven folds on this valve, of which three are on the frontal, and one or two on each lateral part of the valve.

The internal arrangement of this species is as described in the character of the genus, specimens of this species having chiefly served in the delineation of this characteristic.

The structure of the shell can only be seen in one specimen, where it can be ascertained that the shell is distinctly punctate. The punctation is, however, not very fine, much coarser than, for instance, in *Hemiptychina*.

The dimensions of three specimens from Musakheyl are as follows: —

	I.	II.	III.
Entire length of the shell	13 mm.	13 mm.	12 mm.
Length of the dorsal valve	11 „	10 „	10 „
Entire breadth of the shell	11·5 „	10·5 „	9·5 „
„ thickness „	8·5 „	9 „	8·5 „
Apical angle of the ventral valve	91°	80°	80°
„ „ of the dorsal „	117°	117°	122°

Locality and geological position.—This species is not at all rare in the Salt-range, and there were not less than 20 specimens of it in the collection, of which, however, four have been destroyed in trying to ascertain their internal characters. Of these 20 specimens all but two came from the upper region of the middle division of the Productus-limestone. In this latter position the species was found by Dr. Oldham, Dr. Warth, Mr. Wynne and by myself at Musakheyl (eleven specimens); by Dr. Oldham at Swás (two specimens); by myself at Khura (two specimens); and on the road from Vurcha to Uchâli (one specimen). In the Trans-Indus continuation of the Salt-range the species was met with in the same geological position by myself at Káfirkót (one specimen), and by Mr. Wynne in the Paránga Kas (one specimen).

A single specimen was collected by myself in the upper division of the Productus-limestone at Chidru in the *Cephalopoda* bed, in which *Xenodiscus carbonarius*, W., was also found. I detected another specimen at the base of the upper division of the Productus-limestone in a section west of Khura.

Remarks.—This species was excellently described and figured by Mr. Davidson, whose materials all came from Musakheyl, where, beyond doubt, the species is most common, though it is not the only *Notothyris* which occurs at that locality. Nevertheless the species is easy to distinguish from its congeners by its small beak and by the number of its marginal plications, which is never more than three on the frontal region of the dorsal valve.

The species has been rightly compared by Davidson to *Terebr. vesicularis*, Kon., to which it has really a great similarity. A very fundamental difference, however, exists in the entire absence of lateral plications in de Koninck's species, and this difference is yet more manifest if we compare the internal arrangement of the mountain-limestone species (which seems to agree in all respects with that of the *Dielasma* in general) to that of our Indian shell, which in all respects differs widely from King's genus.

A certain similarity to *Hemiptychina himalayensis* exists also, and in some cases it becomes even difficult to distinguish between the two species; but there is in *Hemiptychina* always a certain tendency to form a slightly vaulted frontal line, whilst in *Notothyris*, on the contrary, the tendency prevails to bend the frontal line in the opposite direction, and only in very few specimens can one be in doubt if this character be properly taken heed of.

The species can be considered as characteristic of the upper region of the middle division of the Productus-limestone, as specimens in other geological positions are extremely rare.

2. NOTOTHYRIS DJOULFENSIS, Abich, sp., Pl. XXVIII, figs. 5, 6.

1878. *Terebratula djoulfensis*, Abich: Geologische Forschungen in den Kaukasischen Ländern, I, p. 68. pl. 6. fig. 10.

1879. *Terebratula djoulfensis* (Abich) Möller: Neu. Jahrb. f. Min., etc., page 228.

The general outline of this species is elongately oval or slightly pentagonal

with a moderately large beak, and valves that are generally pretty strongly inflated, and bear only near their margins more or less strong plications, which are always more numerous than in *Not. subvesicularis*, Dav.

The ventral valve is very generally more strongly inflated than the dorsal one, and bears mostly a very equal curvature, so that transversely as well as longitudinally the curvature is about equally strong. Only in some specimens, a sudden bend in this valve appears at the place where the marginal plications commence. The outline of this valve coincides with the outline of the whole shell, and thus, if this valve is more elongately oval, the form of the whole shell is also such; but when this valve is more broadly rounded, and at the same time strongly inflated, a nearly globular shape of the whole shell results. The beak is tolerably thin, not very prominent, but strongly bent over. It is pierced just behind its apex by a not very large oval foramen. The valve is smooth for about half its length from the beak, then there appear tolerably strong, rounded folds, which extend down to the margin of the valve. This latter is distinctly sinuated in the frontal region, so that the indentations corresponding to the folds of the frontal region are situated at a lower level than those of the lateral parts. There are very constantly nine folds on this valve; only in one specimen there are indications of one more fold on each side. Of these folds three are always in the frontal region of the valve, whilst the other six are distributed on both lateral parts.

The dorsal valve is always less strongly vaulted than the ventral one; the difference is, however, in some cases more considerable than in others; but the dorsal valve never becomes quite flat, it being always more or less strongly curved. This curvature is generally only transversely quite regular, but in the longitudinal direction this valve is mostly rather suddenly deflected where the folds commence. The folds are shorter in this valve than in the other one, and two-thirds or even three-quarters of the entire length of the valve remain smooth. There are generally ten folds on this valve, of which four are situated on the frontal part, whose margin is slightly prolonged, corresponding to the sinuation of the ventral valve, and three others are on the lateral parts. Both valves have in this species the peculiarity that in more strongly inflated specimens near the margins a great many imbricating striæ of growth are crowded together, whilst in other specimens these striæ of growth are absent (as, for instance, in the specimen figured by Abich, and also in several of the Salt-range specimens).

Of the internal arrangement of this species only the hinge-plate of the dorsal valve with its large oval foramen near the apex could be observed; the descending branches of the crura were only very rudimentarily exhibited in all the specimens I could spare for the investigation of the internal characters. In the ventral valve the absence of dental plates could also be observed.

The punctation of the shell, which is very well observable in several specimens, is much finer than in the preceding species, nearly as fine as in the genus *Hemiptychina*.

The measurements of three specimens, Nos. 1, and III, from Musakheyl, and No. II, from Swás, are as follows :—

	I	II	III
Entire length of the shell	16 mm.	16 mm.	15·5 mm.
Length of the smaller valve	14 „	14 „	14 „
Entire breadth of the shell	14 „	13 „	12·5 „
„ thickness „ „	12 „	11 „	12 „
Apical angle of the larger valve	80°	76°	70°
„ „ „ smaller „	114°	112°	109°

Locality and geological position.—Of this species, which is somewhat less common than the preceding one, there are altogether ten specimens preserved in the Salt-range collection, all derived from the middle division of the Productus-limestone. This species again is most common at Musakheyl, where it has been collected by Dr. Oldham and Dr. Warth (six specimens). Another specimen was also found by Dr. Oldham at Swás. Mr. Wynne brought the species from Budikheyl (one specimen) and from Kálabágh, Trans-Indus (one specimen). I myself collected this species west of Khura, in beds which were just at the limit between the middle and upper divisions of the Productus-limestone (one specimen).

Remarks.—The identification of the Salt-range specimens with Abich's species does not seem to be in any way doubtful, judging at least by the excellent figure of the species given by Abich. Why his species should not be considered as established, and should be altogether excluded from the list of fossils occurring at Djoulfa, as Prof. v. Möller proposes, I cannot conceive. If the materials for this species, collected by Staatsrath Abich at Djoulfa were not very extensive, the specimen figured by him was beyond doubt excellently preserved, and certainly the species can very well be recognised from it. The occurrence of this form at Djoulfa is not the less interesting, if only a few or even only one well-preserved specimen were found.

The species is very nearly related to *Notothyris subvesicularis*, Dav., but can easily be distinguished by the four folds on the frontal region of the dorsal valve, which is a very constant character of this species, whilst in Davidson's species very constantly only three folds appear on this part of the shell. Abich compares his species rather more to *Hemiptychina himalayensis*, Dav., than to *Not. subvesicularis*.

It must be remarked, that Abich's description of the species is not quite in accordance with the figure on Pl. 6 of the work; and it appears from this description not quite improbable that among the materials which served for the establishing of his species there were really one or more specimens of *Hemiptychina*, leading to the description of several characters which exist in *Hemiptychina*, but not in *Notothyris*. It cannot however be considered in any way as a fault on the part of Mr. Abich, that such a confusion of species should occur; as only a scanty supply of these forms was available, it was absolutely impossible to distinguish between these shells, and it was only natural that all were considered as belonging to one and the same species. The figure unquestionably represents a shell belonging to the genus *Notothyris* and identical with the Indian fossils here described. That the figure on Abich's plate is quite correct I can vouch for, as the plates for Abich's

work were executed by the artist who has drawn the plates for the present work, and I am thus perfectly able to judge of the exactitude of his work.

It cannot be denied that a certain similarity exists also between *Not. djoulfensis*, Ab., and *Hemiptychina himalayensis*, but the two species can always be easily distinguished if one observes the configuration of the frontal line. It is vaulted, with a bend towards the dorsal valve, in *Hemiptychina*, and curved in an opposite direction, with a bend towards the ventral valve, in *Notothyris*.

Notothyris djoulfensis was described originally by Abich from Djoulfa on the Araxes in Armenia. The beds in which the species occurred were considered by him as forming part of the carboniferous formation, but were afterwards recognised by Möller as being of permian age. They are of special interest on account of their containing species of *Cephalopoda* that are generically identical with those of the "Buntsandstein" of the Himalayas, described by Griesbach under the name of *Otoceras woodwardi*.

3. Notothyris Warthi, Waagen, n. gen. et sp., Pl. XXVIII, fig. 1.

The general outline of this species is slightly pentagonal, somewhat longer than it is broad, with a very thick, overhanging but not adpressed beak, and very strong radial folds which commence not far from the apex of the valves.

The ventral valve is not very strongly inflated and its curve not quite equable. It is very strongly arched in the region of the beak, but gets much flatter towards the frontal part. The beak is, as indicated above, very thick, long and strongly overhanging, but quite distant from the apex of the smaller valve, so that below it a large triangular deltidium can be seen, which seems to be made up of two pieces. The false area is very broad and rounded, and extends from both sides of the deltidium and foramen nearly half-way down the length of the shell. The foramen is properly speaking roundish, and pierces the beak far behind its apex. From the foramen, however, there extends an open canal down to the apex of the beak, and this makes the foramen appear of a very elongated oval shape. This valve is smooth just for one-third of its entire length, beginning from the apex of the beak. Then very strong and rather sharp folds appear, which are very generally not more than six in number; only very rarely two additional very small lateral folds occur. Of these folds only two belong to the frontal region, and two on each side are on the lateral parts. As in other species of *Notothyris*, so in this one the margin of the ventral valve is cut out in the frontal region, and the indentations caused by the two frontal folds make the frontal margin appear of a distinctly W-shape, as in *Notothyris subvesicularis*, Dav. The whole valve is covered by numerous striæ of growth, which are, however, not very distinct on the greater part of the valve, and become only conspicuous near the margin, where several successive, strong, imbricating striæ of growth can be observed.

The dorsal valve is nearly regularly pentagonal in shape, and is not quite as

strongly inflated as the ventral one. Its curve is not quite regular, but it is somewhat flattened from the apex down to the beginning of the marginal folds, and then more or less suddenly bends down to the margin. This valve remains smooth over a rather larger area than the ventral one, though the smooth part occupies here also not quite one-half (exactly $\frac{3}{8}$) of the whole length of the valve. The folds then begin gradually but soon attain a considerable height and strength. There are seven folds on this valve, of which three are on the frontal, and two on each lateral, part. The folds are, however, very unequal in size. The two largest and most prominent folds are the two external ones on the frontal region, whilst the median one, as well as the folds on the lateral parts, are much less strongly developed. The margin of the dorsal valve is also somewhat produced in the frontal region to meet the sinuation of the margin of the ventral valve.

Of the internal characters nothing could be observed, but from the external form it is almost certain that the internal characters are those generally occurring in the genus *Notothyris*.

The substance of the shell is very distinctly but very finely granulated.

The measurements of two specimens, No. 1, from Jabi, and No. 2, from Musakheyl are as follows:—

	I.	II.
Entire length of the shell	15 mm.	13·5 mm.
Length of the dorsal valve	12 „	11 „
Entire breadth of the shell	12 „	11 „
„ thickness „	10 „	8·5 „
Apical angle of the larger valve	60°	60°
„ „ „ „ smaller „	122°	117°

The specimen No. 1 is the largest that has been found up to the present.

Locality and geological position.—This species is equally common in the middle division of the Productus-limestone as in the upper division. There are altogether eighteen specimens preserved in the Salt-range collection, of which eight are from the middle division, and ten from the upper division of the Productus-limestone. In the former geological position the species was found by myself at Káfirkót (Trans-Indus) (five specimens), by Dr. Oldham at Swás (one specimen), by Mr. Wynne at Kálabágh (Trans-Indus) (one specimen), and by Dr. Warth at Musakheyl (one specimen).

In the upper division of the Productus-limestone the species was collected by myself at Jabi in the *Cephalopoda* bed together with *Cyclolobus oldhami* (eight specimens) at Chidru, also in the *Cephalopoda* bed, together with *Xenodiscus carbonarius* (one specimen), and by Mr. Wynne at Khund Ghat (one specimen).

Remarks.—This species is rather nearly related to *Notothyris subvesicularis*, Dav. sp., but can be well distinguished from that shell by the length and size of its beak and its much stronger and less numerous folds which commence already at a much earlier stage of growth. The same characters also distinguish this species from *Notothyris djoulfensis*, Ab.

From other non-Indian localities no species is known to me which could be in any way compared to the present one.

4. Notothyris inflata, Waagen, n. gen. et sp., Pl. XXVIII, fig. 2.

The general outline of this shell is very difficult to define. It is not globular, though the thickness is nearly equal to the length of the shell. It is more or less irregularly polygonal, or, seen in the dorsal aspect, it is elongately oval. The beak is thick and large, strongly bent over and firmly adpressed to the apex of the dorsal valve. Both valves are so strongly inflated that they are quite out of shape. They are covered all over by strongly imbricating very conspicuous striæ of growth and bear a few slightly developed folds near their margins.

The ventral valve would be hemispherical if the general outline of its margin were circular; but, as this forms an elongated oval, the form cannot exactly be called hemispherical, though it approaches more or less that shape. Its curve is, however, only tolerably equal in a transverse direction; longitudinally its curve is rather flat for about half the length of the valve, beginning from the beak, and then it descends in a nearly parabolic curve to the frontal margin. The margin is strongly indented, having two strong indentations in the frontal region, and one smaller one on each lateral margin. With these indentations folds correspond, commencing about in the middle of the length of the whole valve, and reaching down to the margin. There are four such folds on this valve, of which the two middle ones are the strongest, and are situated on the frontal part of the valve. Where the folds commence the strong imbricating striæ or folds of growth commence also, and get more and more numerous the nearer the margin of the valve is approached. The beak is thick and overhanging, pierced behind its apex by a tolerably large, oval foramen. The false area is very sloping and not marked off from the remainder of the shell. The deltidium cannot be observed.

The dorsal valve is hardly less strongly inflated than the ventral one, though its inflation is of another kind. This valve is tolerably flat, but little curved down to where the marginal folds commence, which is at about two-thirds of its entire length. Then it suddenly bends very strongly down and even inwards, so that the margin of the valve lies at the same distance from the apex as the place where the marginal folds commence. The folds are five in number on this valve, of which three are in the frontal region and one on each lateral part of the valve. These folds are all very slightly developed and can barely be distinguished among the exceedingly strongly developed imbricating striæ of growth, which cover all the parts of the valve from where the marginal folds commence. They are more numerous near the margin of the valve than further up.

Of the internal characters of this species nothing could be ascertained.

The substance of the shell is as finely punctate in this species as in the preceding one.

The measurements of a specimen from Musakheyl are as follows:—

Entire length of the shell	14 mm.
Length of the dorsal valve	10·5 „
Entire thickness of the shell	11·5 „
„ breadth „ „	10 „
Apical angle of the ventral valve	75°
„ „ „ „ dorsal „	116°

Locality and geological position.—Only one specimen of this species is preserved in the Salt-range collection. It was found by Mr. Theobald at Musakheyl, in the upper region of the middle division of the Productus-limestone.

Remarks.—Though only one specimen of this species is known, yet the general form of it is so singular and widely different from the form of other species that I consider it tolerably certain that the existence of a distinct species is indicated by the specimen. Its peculiarities consist in the great inflation of the valves, the extreme development of imbricating striæ of growth, and the small number of marginal folds, which are less numerous and less strongly developed than in any of the preceding species.

5. Notothyris lenticularis, Waagen, n. gen. et sp., Pl. XXX, figs. 13, 14.

The general outline of this species is broadly pentagonal, about as long as it is broad. The valves are flat and not inflated, the beak small and pointed; there are a few marginal folds, which are, however, restricted to the very margin of the valves. As in other species of Notothyris, so also in this the dorsal valve shows a slight depression in the frontal region.

The ventral valve is regularly, but not strongly vaulted; its curve is, however, somewhat stronger in the region of the beak than towards the front. The beak is thin, strongly bent over, and pierced behind its apex by a very small slightly elongated foramen. The false area is small, not marked off from the remainder of the shell, and does not extend far down to the lateral parts of the valve. The valve is entirely smooth for $\frac{5}{6}$ths of its length, then low and not very conspicuous folds appear, which reach down to the margin of the valve and are always nine in number, three in the frontal region and three more on each lateral part. Striæ of growth cannot be observed on any of the specimens at my disposal.

The dorsal valve is slightly flatter than the ventral one. It is nearly circular or obtusely pentagonal in its outline, and entirely smooth down to near its very margin; the smooth space measured occupies $\frac{6}{7}$ths of the entire length of the valve. The folds are here mere undulations of the margin; there are altogether eight folds present, four in the frontal region, and two on each lateral part. The frontal part of this valve is very little but always and perceptibly depressed.

Of the internal characters of this species nothing could be ascertained. The punctation of the shell-substance is very striking and easily visible; it is very close, but apparently not so fine as in other species of *Notothyris*.

The measurements of a specimen from Khura are as follows:—

Entire length of the shell	15 mm.
Length of the smaller valve	13 „
Entire breadth of the shell	14·5 „
„ thickness „	8 „
Apical angle of the ventral valve	88°
„ „ dorsal „	128°

Locality and geological position.—This species has been found up to the present only at a single locality. This was in the section west of Khura in thin bedded grey limestones at the limit between the middle and upper divisions of the Productus-limestone. The three specimens coming from that locality were collected by myself.

Remarks.—By the number of folds in the frontal region this species appears to be most nearly related to *Notothyris djoulfensis*, Ab.; it can, however, easily be distinguished from that species by its much broader and much flatter form, which is very conspicuous, and by the much less strong development of the folds, which are more strictly limited to the marginal region of the valves. By the same characters, as well as by the greater number of folds in the frontal region, the species may also be distinguished from *Notothyris subvesicularis*, Dav., which appears to be also more or less similar to the present species. Much more strikingly different from *Notothyris lenticularis* are *Not. warthi*, W., and *Not. inflata*, W., and the former species cannot easily be mistaken for one of the other two. Thus *Not. lenticularis* appears to be a well defined species, which is sufficiently distinct from the other species of the same genus to be always easily recognised.

6. Notothyris minuta, Waagen, n. gen. et sp., Pl. XXVIII, figs. 7, 8.

The general outline of this species is roundish, thick, lenticular or nearly globular, with a proportionate beak, and plicated valves, which are smooth only in the apical region. The dimensions of the species are always very small, the largest specimen not attaining more than 10 mm. in length. The ventral valve is generally rather strongly vaulted, though its curve is often not quite regular, as in many specimens this valve experiences a sudden bend soon after the marginal folds have appeared. In other specimens again the curve of this valve is more regular, but then at the same time the valve is generally also less strongly inflated. The beak is comparatively rather small, not long and not firmly adpressed to the apex of the smaller valve. It is pierced behind its apex by a roundish not very large foramen. The deltidium cannot be made out in any of the specimens. The false area is rather broad, not marked off from the remainder of the shell, and reaching laterally more or less far down. The valve is smooth for one-third of its entire length, beginning from the beak. Then strong sharp folds appear, which reach down to the margin of the valve, and are generally seven in number—two are on the frontal, and three on each lateral part.

The dorsal valve is always less strongly vaulted than the ventral one. Its curve is mostly regular, only sometimes a sudden bend appears at the place where the marginal folds commence. The valve is smooth for just half its entire length. Then very strong and sharp folds appear, which reach down to the margin of the valve. There are nine such folds on this valve, of which three are in the frontal region and three on each lateral part. The median part of the frontal region is distinctly depressed, and the median fold on a lower level than the two external

ones, a peculiarity which is not well expressed in the figures, pl. XXVIII. The frontal margin forms thus very distinctly a W-shaped line.

Of the internal characters of this species nothing could be ascertained. The punctation of the shell is well preserved in some specimens, but it is so extremely fine that even with a powerful lens it can only be distinguished with difficulty.

The measurements of two specimens, No. I from the Chittawán, and No. II from Morah, are as follows:—

	I.	II.
Entire length of the shell	9 mm.	7·5 mm.
Length of the dorsal valve	8 „	7 „
Entire breadth of the shell	8 „	6·5 „
„ thickness „	6 „	5 „
Apical angle of the ventral valve	81°	71°
„ „ „ dorsal „	119°	114°

Locality and geological position.—This species is not rare in the middle division of the Productus-limestone. There are altogether eleven specimens of it preserved in the Salt-range collection, of which four were collected by myself in the section near Khura in thin-bedded limestones belonging to the upper region of the middle division of the Productus-limestone. One specimen I found in the mountains east of Katwáhi in the lower region of the middle division. Mr. Wynne collected five specimens at Morah and one specimen in the Chittawán near Ghari, all of them also in the middle division of the Productus-limestone.

Remarks.—This species is rather similar to *Notothyris subvesicularis*, Dav., and *Not. warthi*, W., and might possibly be considered as a dwarfed variety of one of these species, but it would hardly be possible to take it for the young of one of those two forms. The reasons why I have not adopted either of those views are: firstly, that the species now under consideration does not exactly agree in external shape either with *Not. subvesicularis* or with *Not. warthi*. With the first of these forms it has the number of folds and the smallness of the beak in common, while it deviates from it by the strength and extension of the folds. By these latter characters, however, it agrees with *Not. warthi*, from which it differs again just by the characters in which it agrees with *Not. subvesicularis*. Thus the characters of those two species appear to be quite mixed in the present one.

But neither can *Not. minuta* be the young of the two above-mentioned species, as in *Not. warthi* the space for which the valves remain smooth is at least 8 mm. and in *Not. subvesicularis* it is still larger. Thus, if the present species was the young of one of those species, its valves, which never are longer than 9 to 10 mm., ought to be nearly quite smooth or only slightly undulating at their very margins. But just the contrary is the case.

I thus think I am perfectly justified in considering *Not. minuta* as a proper well defined species, which can by its small size alone be easily distinguished from the allied forms. The other characters by which it is distinguishable have already been indicated above.

7. Notothyris multiplicata, Waagen, n. gen. et sp., Pl. XXVIII, figs. 12, 3.

The general outline of this species, which always exhibits very small dimensions, is broadly to elongately pentagonal, with not very strongly inflated valves, which are finely plicated, and a small beak.

The ventral valve is not very strongly but very regularly vaulted. The beak is small, not long, and well bent over, pierced at the apex or barely behind it, by a tolerably large round foramen. The deltidium seems to have been very small, but it cannot be well observed in any of the specimens at my disposal. The false area is not large, rather narrow and reaching down laterally to a very different extent in what we consider narrowly elongated or broadly rounded varieties. On the outside of the beak, just on its most prominent part a furrow commences, which extends over the valve down to where the plications begin, dividing the smooth part of the valve into two halves. The plications begin in this species at different heights in different individuals; whilst in some of them not quite half the length of this valve remains smooth; in others again the smooth part extends over more than two-thirds of the entire length of the valve. The plications are very numerous. There are generally 13 to 14 folds on this valve, of which three to four are on the frontal region. All these plications cause the margins of the valve to be finely serrated; the indentations on the frontal region are on a lower level than the remainder of the margin of the valve.

The dorsal valve is slightly flatter than the ventral one, but its curve is just as regular as that of the other valve. The valve remains smooth for a little more than from half to two-thirds of its entire length. The plications are 15 to 16 in number, which all appear as fine, sharp folds. Of these four to five are in the frontal region. They correspond to a broad, low, but distinct, depression of the valve, which causes the indentations of this part of the margin of the valve to project slightly over the remainder of the valve margin.

Of the internal characters of this species nothing could be ascertained, except that in a specimen with very transparent shell it appears as if a septum extended down on the ventral valve along the median furrow, from the beak to near the middle of the length of the valve; but nothing certain could be made out about it. The punctation of the shell substance is so fine that it is almost microscopic. Even with a very powerful lens it can only be seen under favourable circumstances. The punctation is not very close, but the punctures are very fine.

The measurements of three specimens, Nos. I and II from Musakheyl, and No. III from Morah, are as follows:—

	I.	II.	III.
Entire length of the shell	8·5 mm.	7·5 mm.	7·5 mm.
Length of the smaller valve . . .	7·5 „	6·5 „	6·5 „
Entire breadth of the shell . . .	8 „	6 „	5·5 „
„ thickness „ „ „ . . .	5·5 „	5 „	4·5 „
Apical angle of the ventral valve .	80°	75°	60°
„ „ „ „ dorsal „ . . .	118°	117°	85°

Locality and geological position.—There are altogether three specimens of this species known to me, which all come from the middle division of the Productus-limestone. Two of them were collected by Dr. Warth at Musakheyl, and one was found by myself near Morah.

Remarks.—This is a very strange little species, and it still remains doubtful if it is rightly attributed to the genus *Notothyris*. If it really possesses a septum in the ventral valve, as it appears to do in one of the specimens, its generic position is a very problematic one. As this circumstance could not, however, be positively determined, I have put the species into the genus *Notothyris*, because in its general outline it most nearly agrees with the shells belonging to that genus.

It is not difficult to distinguish this species from other species of *Notothyris* by the much finer and much more numerous folds it possesses. From the species of *Hemiptychina* which are similarly finely plicated, it can be distinguished by its front line, which is curved in an opposite direction.

8. Notothyris simplex, Waagen, n. gen. et sp., Pl. XXVIII, figs. 9, 10, 11.

The general outline of this species is elongately oval or elongately pentagonal with a small beak and a W-shaped frontal line, and no marginal plications except the frontal ones.

The ventral valve is not strongly but very regularly vaulted. The beak is comparatively thin, strongly bent over and firmly adpressed to the apex of the smaller valve. It is pierced far behind its apex by a roundish foramen, from which an open canal descends to the apex, whereby the foramen, if not properly cleared, seems to possess a very elongated oval shape. In most specimens, however, the extreme apex of the beak is broken away, and then the foramen is very small and rounded. The deltidium could not be observed in any of the specimens. The false area is very differently developed in different specimens. In some it is broad and reaches far down the sides of the shell; in others it is very small and limited to the apical region. It is, however, never sharply defined from the remainder of the valve. The valve is smooth for by far the greater part of it, and only quite near the frontal margin the two strong folds appear. Otherwise, only striæ of growth are observable; they are, however, never very conspicuous. The margin of the valve is always, and sometimes very considerably, cut out in the frontal region, so that the frontal part is on a much deeper level than the lateral parts.

The dorsal valve is nearly as strongly and regularly vaulted as the ventral one. This valve is perfectly smooth for by far the largest part of its extent, and only quite close to the frontal margin the three folds appear, of which the median one is the most conspicuous and strongly developed. The marginal part of the frontal region is generally very strongly depressed in this species, and is on a much lower

level than the lateral parts. The striæ of growth are very numerous on this valve and often much more conspicuous than on the other one.

Of the internal characters of this species nothing could be ascertained. As far as could be made out, the substance of the shell seems to be very finely punctated, but it was not possible to be quite certain on this point, as the shell substance was too strongly crystalline to show its structure clearly.

The measurements of two specimens from Katta are as follows :—

	I.	II.
Entire length of the shell	7·5 mm.	8 mm.
Length of the smaller valve	6 „	7 „
Entire breadth of the shell	6 „	6 „
„ thickness „ „ „	5·5 „	4·5 „
Apical angle of the larger valve	70°	65°
„ „ „ „ smaller „	102°	110°

This species seems to grow to considerable size, but the largest fragment does not indicate a specimen of more than 10 mm. in length.

Locality and geological position.— There are altogether ten specimens of this species preserved in the Salt-range collection. Of these the greatest number (eight specimens) were found by myself at Katta in the lowest beds of the compact limestone forming the middle division of the Productus-limestone (bed No. 12 of the section in my note-book); one specimen I collected also myself at Nursingpahár in the identical beds which are there represented by black coaly limestones. The last specimen is somewhat doubtful. It was found by Mr. Wynne at Morah, but it does not exactly agree in shape with the other specimens, and, thus, it is not quite certain whether the species passes up also into the middle region of the middle division of the Productus-limestone, from which this specimen came.

Remarks.—This species is very easily distinguished from the other species of *Notothyris* by the absence of any lateral folds and the more strongly depressed frontal line. It is at the same time the geologically oldest species of *Notothyris* hitherto described. One might well think it a biological fact of some importance that the geologically oldest species should be the most simple one, as regards its sculpturing. It is, however, most difficult to trace the development of the remaining forms from this species. It seems at the first glance as if there were a certain connection between *Not. simplex*, W., *Not. minuta*, W., and *Not. warthi*, W., but by the side of the two latter species appear also all the others described before, and it is impossible to tell whether these should be traced from the same root, or whether they will have descended from other ancestors. As I now could not arrive at any definite conclusion in this matter, I have preferred to simply describe the species without giving any hints as to their probable developmental connection.

Family: *THECIDEIDÆ.*

This family has been long since established, but it was generally considered not to contain any other genera except *Thecidea* and perhaps *Argiope*, and thus the variety of forms comprised in the family was not very great. Even in very recent publications, as for instance in Zittel's Hand-book of Palæontology, no other forms are adduced as belonging to the family.

In former times, however, several fossils were described, which were rightly considered by their describers as nearly assignable to *Thecidea*, but which exhibited so strange an appearance that they might well have deserved a proper generic designation. Such a fossil was, for instance, *Thecidium filicis*, described by Count Keyserling as far back as 1853, from the carboniferous limestone of the Ural, and which was subsequently figured by Möller in the Mountain (Mining) Journal of St. Petersburg. Other fossils, very nearly related to the one just mentioned, were much misunderstood as to their natural relations, and were considered as quite problematical, their systematic position being left quite uncertain. This was the case with a fossil which occurs not very rarely in the Kössen beds of the Alps, and which has partly been quoted as *Bactrynium bicarinatum*, Emmerich, partly as *Pterophloios*, Gümbel, and the affinity of which with *Thecidea* was only recognised quite recently by Zugmayer.

If these fossils are now brought within the family, the range of forms comprised by it will be greatly extended, and still more so when some shells occurring in the Salt-range are taken into consideration. They were mentioned by Zittel in his hand-book (p. 697), from an inspection of my materials, as belonging to *Thecidea* or *Pterophloios*, but it will soon be seen that they are very different from both.

With all these, however, the family acquires such a large extension and comprises so many different and even largely different forms, that either it must be split up into several families, or at least several sub-families must be distinguished. The latter appears to me the more practical way to deal with the matter, as there exists between all the forms which I intend to subsume under the family a decided affinity, which would be lost sight of if several quite distinct families were made of them.

The family characters as defined by Zittel are as follows:—

"Shell punctate, small, fastened or free, with straight long hinge-margin, above which is an area with or without a foramen; brachial loop following the margin of the smaller valve, very often fastened to it and generally with more or less numerous processes, directed towards the inside; cardinal process normally developed."

These characters are only partly applicable if we comprise within the family all the forms I have indicated above. Principally the character of smallness must be withdrawn, as among the Indian shells belonging to the family are specimens which

measure not less than 145 mm. in length, so that they may be counted among the largest Brachiopods known up to the present. A second point which cannot stand as a family character is the existence of an area with pseudodeltidium. Neither those shells which have received the name of *Pterophloios*, nor the species occurring in India, show any trace of an area; a straight hinge-margin is generally present, but it often becomes very short. What Zittel says about the brachial loop may remain; but the character taken from the cardinal process cannot stand, as the Indian species have no distinct cardinal process at all. Thus, after such emendations, the family characters will have to be defined as follows:—

"Shell punctate, of very varying size, mostly attached, sometimes free, and then with a foramen in the ventral valve. Hingeline straight, but of very variable length. Brachial loop following the margin of the smaller valve, mostly fastened to it for its entire extent, and generally with more or less numerous processes directed towards the inside."

Only under this definition can all the forms belonging to the family be brought. Among the forms thus subsumed several groups may, however, be very conveniently distinguished, and may well be considered as forming sub-families. One of them has already been distinguished by Dall, but it was considered by him as forming part of the *Terebratulidæ*. This is the sub-family *Megathyrinæ*, Dall, forming a very convenient transitional link between the *Terebratulidæ* on the one hand and the *Thecideidæ* on the other.

The characters of the sub-family might be subsumed under the following diagnosis:—

Sub-family: *MEGATHYRINÆ*, Dall.

"Shell small with a long straight hingeline and a more or less large area in both valves, in which a very large round foramen is placed. Brachial loop free for its greater extent, sometimes lobed, only attached at certain places along the margin of the dorsal valve."

The genera belonging to this sub-family are not numerous; only one, indeed, has been recognised as of proper standing, the others being considered by most writers as sub-genera only. The one which is beyond doubt a genus by itself is—

Argiope, Desl. (*Megathyris*, Bronn). The characters of this genus are sufficiently well known and need not be repeated here. The genus begins very sparingly in jurassic times, and passes up through the cretaceous period to the tertiary and recent formations.

Another genus is—

Cistella, Gray, 1853 (Cat. Brit. Mus. Brachiopoda, p. 114). Different from *Argiope* by a single large median septum in both valves; has its geologically oldest representatives in liassic strata, and reaches up into the living fauna. Dall considers the genus as well separable from *Argiope*, whilst, according to Zittel, it constitutes only a sub-genus of the latter genus. I am myself more in favour of Dall's opinion.

ZELLANIA, Moore (Davidson Brit., Ju. Brach, p. 141). This is a rather doubtful genus. It is said to possess a fibrous shell. Otherwise it has a median septum in both valves, as *Cistella*, and is therefore considered by Dall as identical with that genus. It has up to the present only been found in the lias of England.

The numbers of genera belonging to the sub-family is for the present limited to these three. The transitional character of this sub-family between the *Terebratulidæ* and the *Thecideidæ* consists in the presence of a large foramen for the passage of a pedicle, and in the brachial loop, which is free for its greater extent and attached only to the inwardly directed processes proceeding from the margin of the smaller valve, which are so characteristic for the Thecideidæ.

The next sub-family which can be distinguished has also been already established by Dall; it is the

Sub-family: *THECIDEINÆ*, Dall,

which may be characterised in the following manner:—

"Shell of variable size, mostly small, solid, attached by the larger valve; hingeline straight, mostly an area and pseudodeltidium on the ventral valve; brachial loop lobed and united more or less firmly with the dorsal valve; cardinal process generally tolerably well-developed."

The only genus that up to the present has been known to be comprised in the sub-family is

THECIDEA, Defrance, 1828 (*Thecidium*, Sow.). This is a sufficiently well-known genus, and its characters need not be repeated here. The geologically oldest species begin to appear in the trias, and thence up to the present times they are represented in all the formations. In the Alpine trias, however, there appear at the side of the true Thecideæ yet other forms which have received from Gümbel the name of

PTEROPHLOIOS, GÜMBEL, 1861 (Geogn. Beschr. d. bayr. Alpengeb., p. 411). Already Gümbel suspected the Brachiopod-nature of these fossils, but it was not before the year of 1880 that Mr. Zugmayer was in a position to prove their affinity beyond any doubt, and to demonstrate that they were most nearly related to *Thecidea*, Defr. Mr. Zugmayer, however, went too far in this direction, inasmuch as he united *Pterophloios* entirely with *Thecidea*. Though a certain affinity between the two fossils can certainly not be denied, yet their generic union cannot be advocated. *Pterophloios* is different in certain very important points from *Thecidea*. In the large ventral valve the area and pseudodeltidium are decidedly absent, the cardinal teeth are very little developed, and a long and strong median septum extends from the apex to the anterior margin. Traces of numerous radial septa are also present. In the smaller dorsal valve the cardinal process is very small, but otherwise the arrangement of the brachial apparatus is very similar to that of Thecidea. It now appears to me that the peculiar structure of the ventral valve is sufficient to distinguish generically between *Thecidea* and *Pterophloios*, and that thus the latter genus might very well be retained.

There are yet some remarks to be made as to the name these fossils ought to bear. Already, in 1855, Mr. Emmerich gave the first description of fossil remains belonging to *Pterophloios* (Yahrb. K. K. Geol. Reichsanst. Vol. VI, p. 449) under the generic designation *Bactrynium*, Heer. Now, Mr. Zugmayer, in preparing his "Untersuchungen über rhätische Brachiopoden," took great pains to find out what was meant by the name *Bactrynium*, and as he could not find anywhere in the literature that name as given by Heer, he at last wrote to that author himself, and got the answer that Heer never had created a genus *Bactrynium*. As now there exists a genus *Bactrillium* by Heer, employed for fossil plants, it is highly probable that Emmerich took these little fossils to be plants and meant to compare them with *Bactryllium*, which by a misprint was changed into *Bactrynium*. Thus the name cannot be employed, it having never had a real existence. Therefore *Pterophloios*, Gümb., is the only name which stands by right for these fossils.

There is only one species of this genus known up to the present. Since a long time it has been found off and on in rhætic beds of the Alps, but was always considered as an exceedingly rare fossil, until M. Zugmayer showed that it was not rare at all, but that it occurs in considerable numbers at certain localities. Except in the rhætic beds nothing similar has been detected in Western Europe.

There is yet another fossil which bears a great resemblance to *Pterophloios;* it is *Thecidea filicis*, Keyserling, from the upper carboniferous limestone of the Ural. A single specimen has been found up to the present, by Wangenheim von Qualen, and has been described by Count Keyserling and Möller. It is, as indicated by the latter, a dorsal valve only, of considerable dimensions. Neither from the description, however, nor from the figure (of which Pl. XXXI, fig. 10, is a copy) is it quite clear whether this fossil is more nearly allied to *Pterophloios* or to the fossil from the Salt-range, which I shall presently describe under the name of *Lyttonia*, Waagen. On the whole it is probable that a proper and distinct generic type is represented by the fossil from Sterlitamak, but the materials available are too scanty to say anything positive on that score.

There remains yet one more sub-family to be established within the *Thecideidæ* solely made up of Indian fossils. The shell in question has long been known, but has never been recognised as a Brachiopod. It had been described by Koninck as a *Bellerophon*. But that author in describing it was very doubtful as to its real relations to other fossils, and he expressed these doubts in the name which he gave to the species, as he called it *Bellerophon decipiens*. In working out these shells from the rock I was very much struck with the extraordinary structure they exhibited. C. Schwager, Custos of the Royal Palæontological Museum of Munich, first drew my attention to their similarity to *Pterophloios*, Gümb.; but as at that time the fossils bearing that name were among the most obscure known, not much was gained by the detection of this similarity.

After much painstaking I came to suspect a certain relation between the Indian fossils and *Thecidea*, but I was not able to prove anything. It was there-

fore with very great pleasure that I learnt Mr. Zugmayer's very meritorious discovery of *Pterophloios* being a *Thecidea*. Then only, though there still exist great differences in structure between the Indian fossils and *Pterophloios*, was I in a position to assign to the Indian specimens a definite place in the system.

The peculiarities exhibited by these fossils are so great that it becomes necessary to create for them a proper sub-family, for which I introduce the name of

Sub-family : *LYTTONIINÆ*, Waagen.

"Shell of large size, flat or vaulted, attached by the larger valve; hingeline strait but short, no area or pseudodeltidium; internally, the ventral valve with a median and numerous lateral septa; dorsal valve rudimentary, forming together with the brachial apparatus one strongly-lobed shelly plate, which fits between the external septa of the large valve."

From this definition it appears clearly in what essential points this sub-family deviates from the *Thecideinæ*. Yet I think these forms ought to be retained in the family *Thecideidæ*, as the most striking characters of the family, the punctate shell, the lobed brachial apparatus, and the attached larger valve persist, though under such very strange modifications.

There are two genera which I comprise in the sub-family, the genus *Lyttonia*, Waagen, n. gen., and the genus *Oldhamina*, Waagen, n. gen.

The genus LYTTONIA, so far as known, is exclusively of eastern distribution. Two species of it occur in the Salt-range as well as in the Himalayas; a third species has been described by Kayser as a fish-tooth under the name of *Leptodus richthofeni* from the upper carboniferous beds of Lo-Ping in China.

The genus OLDHAMINA is still more restricted in its geographical range, and has up to the present only been found in certain beds of the Salt-range, unless the *Thecidea filicis*, Keys., already several times mentioned, belongs after all to this genus. There are at least some points given in the description by Möller which could be adduced in favour of the opinion that he had to deal with an *Oldhamina*. Möller says: "On the inside of the dorsal valve there is a shelly plate which served for the support of the hand-shaped labial appendages of the animal. This very fine plate rests on the bottom of the valve in the hollow which is marked on each side by a prominent ridge; it proceeds from the cardinal part of the shell where it is fixed on both sides. From here it extends towards the frontal margin, forming four lobes on each side of the middle line. Near the frontal margin both the lateral parts of this plate curve round and return straightway to the cardinal region, where they unite from both sides."

This description appears to be as well applicable to the apophysary ridge or the "appareil descendant" of Deslongchamps in *Thecidea*, as to the dorsal valve of *Oldhamina;* but if the latter were the case, the specimen from Sterlitamak would not be the dorsal valve only, but would consist of the ventral valve with the dorsal one resting on it. But then the dorsal valve would be in this species still more

rudimentary than it is in the Indian specimens of *Oldhamina;* the curve of the ventral valve would, moreover, be the opposite way, so that the dorsal valve would be convex and the ventral concave, just the opposite of what is the case in some of the Indian fossils. It would be extremely desirable to learn something positive on all these details, and it is to be hoped that some fortunate finds in the beds of the Ural will throw more light on the very obscure relations of this highly interesting fossil.

With regard to the development in time of the whole family of *Thecideidæ*, we find that the geologically oldest species known up to the present is *Thecidea filicis*, Keys. I have stated above, that what is known up to the present of this fossil admits of no certain conclusion as to its real structure; there are, however, some indications that the dorsal valve was a mere thin-lobed plate, split up in the middle in two halves by a deep sinuation extending from the frontal margin to near the cardinal region. Next in the series, but not far removed in time from the preceding species, come the forms from the Salt-range, for which I have introduced the names *Lyttonia* and *Oldhamina*. In these species also the dorsal valve is still rudimentary to a certain extent: but there is already a solid middle piece developed, and only the lateral incisions are as yet present, by which the lateral parts of the valve become lobed. After the disappearance of *Oldhamina*, which takes place probably at the upper limit of the palæozoic series, a very long time elapses during which we know nothing of the family. The next member that we are acquainted with is *Pterophloios*, which occurs in rhætic beds, that is to say in the uppermost division of the triassic period. This genus approaches more the type of *Thecidea* proper. The projecting ridges of the ventral valve, which are so remarkable a feature in *Lyttonia*, have almost disappeared, the dorsal valve has changed into a solid shelly mass with entire margin, and only on the inside of this valve can the characteristic figure of the dorsal valve of *Lyttonia* be recognised. Along with *Pterophloios* true *Thecideæ* occur, and with these the family has already attained the development which it exhibits in the recent seas. The sub-family *Megathyrinæ* appears to be a lateral branch of the same stem, of which it is, however, not yet known for certain at what time and in what manner it branched off.

Sub-family: *LYTTONIINÆ.*

Genus: LYTTONIA, Waagen, n. gen.

1878. *Bactrynium* (Emmer.) Waagen: Records, Geol. Surv. of India, Vol. XI, pp. 186, 187.

1880. "The unnamed fossil of the Salt-range," Wynne: Trans-Indus extension of the Salt-range, Mem. Geol. Surv. of India, Vol. XVII, p. 210.

1880. *Thecidea* (Defr.) Zittel: Handbuch der Palæontologie, I, 1. p. 696, 697 (pars.)

1880. *Thecidea* (Defr.) Zugmayer: Untersuchungen über rhätische Brachiopoden: Beiträge zur Palæontologie von. Östreich-Ungarn, I p. 22. (pars.)

1882. *Leptodus*, Kayser, n. gen.: Richthofen's China, Vol. IV, p. 161.

Shell strongly inequivalve composed of a solid larger valve and a rudimentary smaller one. The larger valve is generally attached for its whole extent, flat and

very irregular in its shape, sometimes very thick and heavy, sometimes moderately so. It bears sometimes great lateral expansions, which cover large surfaces of rock. No distinct apex is developed; a short straight hingeline, surrounded by more or less largely expanded shelly parts, termimates this valve in the cardinal region. The outer surface of this valve is but rarely visible; it bears irregular undulating striæ of growth, which are more or less distinctly interrupted along the middle line of the valve. The inside is most characteristic. The most striking character consists in numerous lateral septa which extend in a slight curve, concave towards the cardinal region, from near the lateral margins of the valve to near its middle, where they leave a more or less broad smooth space, in the middle of which in most cases is a narrow vertical septum, extending from near the cardinal to the frontal region of the valve. In all these features more or less irregularity prevails according to the inequalities of shape of the whole valve.

The cardinal region needs a separate description. The vertical median septum generally stops a short way before it reaches the cardinal region, and in the smooth space thus formed in many specimens tolerably sharply defined, elongated, diverging impressions can be discerned, one pair on each side, the margins of which are slightly raised. These impressions will very likely have to be considered as muscular scars. Above these, very near the short straight hingeline, and joined to the first rudimentary lateral septum are the hingeteeth, narrow, thin, diverging ridges, which are, however, very badly developed in this genus, and often cannot be well distinguished. The space between the lateral septa is everywhere irregularly grooved and punctured. Wherever this large valve is not covered by the rudimentary smaller one, it is distinctly and finely papillated.

The smaller valve is rudimentary, as has been frequently stated, and thus it covers the larger one only partially, so that the latter projects everywhere below the smaller one. It consists of a more or less large solid middle piece, to which are joined on both sides more or less numerous wing-like appendages, which fit between the lateral septa of the larger valve. The middle piece is broader and more compact in the cardinal region, and narrower, corresponding only to the median space between the lateral septa, towards the front. It is by no marked feature distinct from the lateral wings. The whole valve is flat, like the ventral one, and all covered on the outside by very fine papillæ. The solid middle piece bears in the cardinal region shallow transverse impressions corresponding to the lateral septa of the large valve, which at certain irregular places become somewhat deeper, so that more or less large holes are formed piercing the valve. The holes begin to be formed as near to the cardinal end of the valve as to the lateral margin of it. Further down these holes extend more and more inside the shell as well as outside, so that they soon become narrow deep incisions, by which the whole valve is cut up in narrow laterally-extending branches, which are united only in the middle by the solid shelly piece, extending from the cardinal region of the valve down to the frontal margin. Into these incisions fit the lateral septa of the larger valve. Along the centre of the

solid middle piece a narrow but not sharp furrow runs along, corresponding on the inside of the valve to a median septum.

The inside of the valve bears few remarkable features. The brachial loop seems to have consisted only of a sharp prominent ridge, lobed much in the same manner as in the dorsal valve of *Pterophloios emmerichi*, Gümb., and attached for its entire length to the substance of the valve. In the short straight hingeline there is a very small bipartite cardinal process, which appears as the cardinal termination of the median septum. There is no specimen in which I could observe the dental grooves on the side of this process or the commencement of the loop; but there is very little doubt that the sharp prominent ridge bordering the lateral incisions of the valve must be considered as forming part of the loop, as this ridge extends in the cardinal region also on the solid part of the valve, forming high crests with a furrow on the top, into which fit the lateral septa of the ventral valve.

The substance of the shell is made up in the ventral valve of two layers, an outer one, which is very thin and solid, but is very rarely preserved, as mostly the whole underside of this valve is attached; and an inner one, which is often very thick, and is always very distinctly punctate. The dorsal valve is only made up of the punctate shell-substance. There are up to the present three species of this genus known to me, of which two occur in the Productus-limestone of the Salt-range, and will bear the names of *Lyttonia nobilis*, Waagen, n. gen. et. sp., and *Lyttonia tenuis*, Waagen, n. gen. et sp. The third species has been described by Kayser from the upper carboniferous limestone of Lo-ping in China, and must be quoted as *Lyttonia richthofeni*, Kays, sp.

This latter species was originally described by Kayser under the name of *Leptodus richthofeni*, and it requires some words of explanation why I do not use the generic name *Leptodus* for the fossils under consideration. M. Kayser was very doubtful as to the systematic position of these fossils, but at last he decided on their being fish-teeth. That author did not know that the fossil was bivalved, as all his specimens showed only one valve, and thus the mistake is very well explainable. Nevertheless I should gladly have used M. Kayser's name, had it not been unfortunately just such an one as is only applicable to fish remains, and cannot possibly be used for brachiopodous shells. Thus I was compelled to make a new name, and I introduced the name of *Lyttonia* in honour of Lord Lytton, under whose auspices this work was begun.

1. Lyttonia nobilis, Waagen, n. gen. et sp., Pl. XXIX, XXX, figs. 1, 2, 5, 6, 8, 10, 11.

This large and beautiful species is not rare in the Salt-range, but is very rarely met with in complete specimens, and the specimen figured on Pl. XXIX is the only one I detected in a tolerably perfect state.

When perfect the shell is of very considerable dimensions, flatly spread out, and attached by the entire underside of the ventral valve. Owing to this circumstance it is often very uneven, and irregularly curved in all directions, according to the curvature of the body to which it is attached. But also laterally very often distortions take place, the cause of which cannot always be easily understood. From all these circumstances, it is evident that the general outline of the shell must be very irregular,—so much so, that it becomes very difficult to give a general idea of its shape and outline.

The shell is always longer than wide. Sometimes it terminates in the cardinal region in a tolerably long and straight hingeline, nearly as long as the broadest part of the shell; sometimes it is rounded at both ends and bears only a very short straight hingeline in the cardinal region. The lateral margins vary very irregularly, bending out and in as the nature of the body to which the valve is attached permits. They are sometimes bent up, but sometimes also so largely spread out over surfaces of rock that the proper limits of the valve cannot be made out. More commonly than on the lateral margins, such expansions occur in the cardinal region where the ventral valve often appears as if rolled up, from the shelly expansions, which are turned over the somewhat elevated hingeline, and descend again to the supporting rock surface to be again attached. In other specimens these expansions are very little developed, there being great variation in this respect.

The substance of the ventral valve is comparatively thick and heavy. Where sometimes for short distances it is not attached, two shell layers can be distinguished, one outer, rather compact and covered by numerous striæ of growth, and an inner one composing the greatest thickness of the valve and made up of many thin lamellæ. This inner layer is more or less distinctly porous, and the pores are chiefly distinct and numerous along zones on both sides of the lateral septa, which penetrate the inner shell layer.

On the inner side of the ventral valve the lateral septa, so characteristic of the shells of this whole sub-family, are developed with high crests, and are present in large numbers. In the specimen figured on Pl. XXIX there are about thirty-three such septa on each side of the middle line. None of these septa reaches the very edge of the lateral margins, but the whole valve is bounded by a smooth space of shell, which is not very broad in the specimens with bent-up margins, but which is very much extended in specimens bearing lateral expansions. The septa are sometimes very irregular in their development; sometimes they bifurcate towards the lateral parts of the shell, and are otherwise bent in different directions, or they are interrupted for a short distance and reappear further on.

Towards the cardinal region they become gradually more and more short and the last two are quite rudimentary. The last pair is strongly inclined, converging towards the hingeline, and apparently must be considered as replacing the cardinal teeth. Inside of these teeth, more towards the middle of the valve, two pairs of elongated longitudinally striated, slightly raised bodies can be observed, which perhaps served for the insertion of muscles.

The dorsal valve is much thinner in its substance than the ventral one. I have no specimen in which the entire hingeline and its internal apparatus is observable; but otherwise this valve bears very peculiar characters, which enables it to be easily distinguished from the same valve of other species. In this species the whole valve is surrounded by a continuous smooth margin so that the incisions, which in general characterise the dorsal valve of the shells belonging to this sub-family, appear in this species as perforations of the shell. These perforations are generally long narrow slits extending from the smooth shell margin to near the middle line of the valve, and into which fit the lateral septa of the ventral valve. In the cardinal region these slits are more and more limited to the lateral parts of the valve, and are often bridged over by shelly substance, so as to be divided into several parts.

On the outer surface of the valve a distinct, longitudinal median impression, corresponding internally to a longitudinal septum, is present. The whole outer surface of this valve is covered by very numerous small papillæ.

The dimensions of the only tolerably complete specimen that has been found up to the present are as follow:—

Entire length of the shell	145 mm.
„ breadth „	87 „
Thickness of the entire specimen	28 „
Thickness of the section through both valves in the cardinal region .	9 „

Locality and geological position.—The species is chiefly numerous in beds belonging to the middle division of the Productus-limestone. The most complete specimen was collected by myself at Virgal, in a friable crinoidal limestone interbedded with compact coral limestones. This specimen is exposed on the ventral or attached valve, a circumstance which has very likely been caused by its having been fastened originally only to loose crinoidal detritus. Both its valves are preserved. Besides this complete specimen two fragments of the ventral valve were collected by me at the same locality in the same beds. The locality where the greatest number of specimens, all fragments of the ventral valve, were found is Morah. All these specimens (12) were collected by Mr. Wynne in a hard silicious limestone forming probably part of the middle region of the middle division of the Productus-limestone. At other localities only sporadic specimens have been found. A large tolerably complete specimen (ventral valve) was collected by myself in the upper beds of the calcareous series forming the middle division of the Productus-limestone at the village of Khura. Another fragment, silicified, was found by Dr. H. Warth at Musakheyl. Also Trans-Indus the species seems not to be rare. It has been collected by Mr. Wynne at Kálabágh (1 ventral valve), and at Bilot (5 fragments, among them a tolerably large fragment of a dorsal valve).

Remarks.—There is only one species to which the present form can be compared. This is *Lyttonia richthofeni*, Kays, sp., of which only ventral valves have been found, and these rather imperfect, the inner surface being always concealed by rock matter, so that the configuration of the inside is only known from internal casts. From what we know of these fossils, it is, however, almost certain that they are

specifically distinct from *Lyttonia nobilis*. The whole form of the shell seems to be smaller and more triangular, its substance is apparently much thinner, and on the inside the longitudinal median septum seems to be absent. A point of difference may also exist in the greater flatness of the shell of *Lyttonia nobilis*.

Another very similar species is *Lytt. tenuis*, Waagen, which I shall describe next. This form is distinct from the present species chiefly by its less compact shell and a differently developed dorsal valve.

2. LYTTONIA TENUIS, Waagen, n. gen. et. sp., Pl. XXX, figs. 3, 4, 7, 9.

Among all the materials of this species from the Salt-range there is not a single entire specimen, and therefore it becomes very difficult to say anything positive on its general outline. It seems that this was more roundish and less elongated than in *Lytt. nobilis*, but nothing certain can be said about the point. In this species also great irregularities of shape occur, but apparently less extensive and less frequent than in the preceding species. It is also much smaller.

The ventral valve is exceedingly thin, barely attaining the thickness of ordinary paper. Its outer surface is never visible, being always firmly attached for its whole extent. Internally the valve exhibits the features generally found in shells belonging to the sub-family. The median longitudinal septum is very strongly developed, and the numerous lateral septa are very thin and sharp. Owing to the extreme thinness of the valve these lateral septa are in many specimens imperfect, and bear a more or less deep furrow at top, sometimes so deep as to penetrate the whole shell substance, and then the ventral valve becomes as well lobed as the dorsal one, with the sole difference that the incisions between the single lobes are extremely narrow in the ventral valve. These incisions occur only in specimens in which lateral and cardinal expansions are absent. Mostly, however, such expansions are greatly developed and often cover large surfaces of rock, and then there are either only furrows on the top of the lateral septa, or these form narrow sharp and high crests.

The shelly expansions are always rugose, with numerous comparatively large papillæ covering their whole surface.

The cardinal apparatus is in this species much like that in the preceding one. The teeth are badly developed and are united to the first pair of lateral septa, which is somewhat more sloping than the others. Between the cardinal teeth the same impressions are found as I have described in the preceding species, and which I take to be muscular scars; but in many specimens they are very indistinct.

The dorsal valve exhibits many highly characteristic features. The solid central piece is very much reduced, and in the cardinal region is not more extended than elsewhere. There is no continuous margin bordering the whole valve, and the incisions reach the edge so that it appears to be divided into a number of long and narrow lobes, which are generally only united in the solid middle piece. The outer surface of the valve is covered with very numerous comparatively large papillæ, making it more or less strongly rugose.

On the inside this valve is very characteristic. As in *Lytt. nobilis*, the lateral incisions are bordered all round by a sharp high ridge, which I consider as forming part of the brachial apparatus. In one specimen collected by Mr. Wynne at Bilot, there seems to rest between these ridges on the bottom of the valve a very thin shelly lamella, which in its shape follows entirely the shape of the valve, but which cannot be observed for its whole extent, as it appears to be only partly preserved. Along its margins this lamella is distinctly fringed, and chiefly at the interior angles of the incisions towards the solid middle piece long and numerous fringes can be seen. There is but little doubt that this lamella must be considered as representing the "appareil descendant" of the *Thecideidæ*, and the occurrence of it in a specimen of *Lytt. tenuis* is a further proof that these very strange fossils must be considered as forming part of that family. The inner side of the apical region is not distinctly exposed in any specimen, and therefore I am not in a position to describe that part accurately. There is a thickening at the termination of the longitudinal median septum, in the middle of the short straight hingeline as in *Lytt. nobilis*, which might be compared to a cardinal process, but otherwise nothing can be seen.

There is no entire specimen of *Lyttonia tenuis* preserved in the Salt-range collection, and therefore I am not in a position to give any measurements. On the whole it can be taken for granted, that this species never attains the very considerable dimensions of *Lytt. nobilis*.

Locality and geological position.—This species is more common than the larger and more solid *Lyttonia nobilis*, but it is always found only in fragments. Already by the early observers it had been collected, and it was apparently only by chance that no specimen of it was among the materials sent by Dr. Fleming to Messrs. Davidson and de Koninck; as Mr. Theobald, then Dr. Fleming's assistant, presented several specimens to the collections of the Geological Survey of India. One of these, the one figured on Pl. XXX, fig. 4, had been considered by Mr. Theobald as the pygidium of a Trilobite, and therein originated the report that Trilobites were found in the Salt-range. These old specimens, two in number, both fragmentary duplicates, were collected in the upper beds of the middle division of the Productus-limestone of Musakheyl.

Of the specimens procured during the preparation of the geological map three fragments of the ventral valve were collected by Mr. Wynne at Swás in the middle division of the Productus-limestone, and two also fragmentary specimens I found myself in the same horizon west of Khura. At the section near the village of Khura I collected one specimen in the thin-bedded limestones, forming there a transitional link between the middle and upper divisions of the Productus-limestone.

The species is much more abundant in the Trans-Indus extension of the Salt-range. It has been collected there by Mr. Wynne everywhere in the middle division of the Productus-limestone, and is represented in the collection by the following specimens: Paránga Khas west of Chicháli (one specimen, ventral valve), Káfirkot north (seven fragmentary specimens, all ventral valves except one), Gulámi (one specimen), Bilot (six specimens).

Remarks.—This species, especially in fragments, is not always easy to be distinguished from the preceding one, and often the determination of such fragments remains doubtful. In general the much less massive development of the lateral septa in the ventral valve, and the extreme thinness of this valve, which often covers the rock surface only as a thin film, are safe characters. In all the specimens I have seen of this species the whole underside of the ventral valve is attached; I have never seen even the margins bent up and detached from the rock, as is often the case in *Lyttonia nobilis*.

The dorsal valve, which is far more rarely met with than the ventral one, can easily be distinguished by the absence of the continuous margin, and the very small extension of the solid middle piece in the cardinal region.

Of other species *Lyttonia richthofeni*, Kays, sp., must still be compared. I do not think it likely that the present species will ever be mistaken for the Chinese one, as in the latter the ventral valve seems to be free nearly for its whole extent, whilst it is attached for its whole extent in *Lyttonia tenuis*. The dorsal valve of *Lyttonia richthofeni* has not been detected up to the present.

3. Lyttonia cf. richthofeni, Kays, sp.

1882. *Leptodus richthofeni*, Kayser: in Richthofen's China, Vol. IV, p. 161, Pl. XXI, figs. 9-11.

There is a tolerably large fragment of a single ventral valve, which exhibits a very thin shell substance and has not been attached. The outer surface is well preserved, covered by very numerous irregular striæ of growth which are bent up and indistinctly interrupted in the middle.

The inner surface is not exposed, but it can be seen in section that it possessed numerous lateral septa such as occur in other species of *Littonia*.

Locality and geological position.—The only fragment of this species was collected by myself in the middle division of the Productus-limestone at Khura.

Remarks.—This fragment is certainly very nearly related to *Lytt. richthofeni*, but nevertheless I should not like to identify it directly with that species, as the Indian fossil seems to have attained a much larger size than the Chinese specimens, and seems in its general outline to have been much more elongated than any of them. Yet the materials in my hands are not sufficient to make a proper species of it, though it is not improbable that a distinct form is represented.

Genus: OLDHAMINA, Waagen, n. gen.

1863. *Bellerophon* (Montf.) Koninck: Quart. Journ., Geol. Soc., Lond., Vol. XIX, p. 8.
1863. *Bellerophon* (Montf.) Koninck: Foss. paléozoiques de l'Inde, p, 15.
1880. *Thecidea* (Defr.) Zittel: Handbuch d. Palæontologie, I. 1, pp. 696, 697 (pars.)
1880. *Thecidea* (Defr.) Zugmayer: Untersuchungen über rhätische Brachiopoden Beiträge zur Palæontologie von Östreich-Ungarn, I, p. 22 (pars.)

The shells belonging to this genus have been long known, but they have always

been considered as univalve, and were in consequence compared by Mons. de Koninck to *Bellerophon*. That author, however, had only one not very well preserved specimen at his disposal, and thus it can easily be conceived that he could not get access to the second valve, which is very generally concealed by rock matter.

I too experienced great difficulty in trying to make out the characters of the smaller valve. That the shell was bivalved I was very soon convinced by a specimen I collected at Jabi, in which the larger valve was partly broken off and the smaller one appeared below, but the distance between the two valves was so very small that only close investigation removed every doubt as to the nature of the smaller valve.

Thus the shell is composed of two valves, one smaller and one larger, corresponding respectively to the dorsal and the ventral valves of the Brachiopoda. The ventral valve is much more solid, compact, and externally entirely smooth, only covered by tolerably numerous concentric striæ of growth. It is at the same time very strongly vaulted, nearly hemispherical, and strongly bent over in the apical region. In consequence of this the hingeline is not visible, being covered up by a thick callosity, which envelopes the apical part of the valve and extends on both sides in wing-like expansions, rolled up spirally. The shape of the callosity is otherwise very irregular. During earlier stages of growth the valve is attached by the apex, but later on it becomes free. Internally the characteristic septa of the sub-family *Lyttoniinæ* are developed. The hingeline can only very rarely be observed: it is straight and generally somewhat longer than in *Lyttonia*, and forms a deep angular furrow, which is not interrupted in the middle. Below it and not in connection with it are the well-developed hingeteeth, joined to the first pair of lateral septa, and forming high, sharp, diverging ridges, elevated sharply above the crest of the septa. The muscular scars, which are so conspicuous in *Lyttonia*, are absent in this genus.

The dorsal valve is constructed very much as in *Lyttonia*. It is strongly concave, and consists of a longitudinal solid middle piece, to which are attached laterally long, narrow, shelly lobe sseparated from each other by deep narrow incisions, into which fit the lateral septa of the ventral valve. Internally the incisions are surrounded by high sharp ridges, which very likely must be considered as representing the brachial apparatus. The cardinal region of this valve is developed somewhat differently from that of *Lyttonia*. The hingeline is straight with a somewhat sloping margin. The longitudinal median septum terminates at the hingeline in a kind of cardinal process, which, however, does not project above the hingeline. It is divided very much in the manner of the cardinal process of the smaller valve of *Productus*. In its general shape it is rhomboid, composed of four longitudinally-placed lamellæ. From both lateral angles of the rhomboid descend sharp sloping ridges, behind which, towards the hinge-margin, the dental sockets are placed. These latter are rather broad triangular grooves, which cannot have been

filled up by the narrow cardinal teeth. The whole hinge-apparatus has not become quite clear to me, but from the investigation of many specimens the interpretation of the parts as I have given it seems the most probable one.

Externally the dorsal valve as well as the callosity of the ventral one are finely papillate.

Though externally these shells seem to be rather different from *Lyttonia*, yet in reality there exists a very great affinity between the two genera. The internal arrangements are nearly all identical, and the chief difference consists only in the great inflation of the ventral and the corresponding concavity of the dorsal valve, the callosity in the cardinal region of the ventral valve, and the generally unattached state of the whole shell. It was these very distinguishing characters that led to an entirely different opinion as to the nature of these fossils in comparison to *Lyttonia*. Both were considered by former writers as univalve; but while the flatly-spread shell and singular structure in *Lyttonia* suggested the appearance of fish-teeth, the strongly inflated nearly hemispherical state of the shell of *Oldhamina* induced the observers to consider these fossils as Bellerophonts. It needs only a glance at the figure on Pl. XXXI to show the similarity to those univalve Mollusks, and how intelligible it is that in the absence of any other comparable fossils, and under the impression of their being univalved, these shells were taken for Bellerophonts. That the presence of a second valve excludes the Bellerophon-nature of these shells absolutely has been already remarked.

There have, however, been recently described more accurately some fossils which do bear a great resemblance to *Oldhamina;* they compose the genus *Pterophloios*, Gümb. The ventral valve of *Pterophloios*, looked at from the outside, appears exactly like a very small species of *Oldhamina*, and differs from the latter only by the absence of those irregular expansions or wings in the cardinal region, as well as of the callosity. As, however, these characters are very little developed in young specimens of *Oldhamina*, it cannot be denied that the similarity is really very great, and it is quite justifiable that Zittel as well as Zugmayer, only from the superficial inspection of my materials, thought it proper to directly unite the Indian fossils with *Pterophloios*,—that is to say, with *Thecidea*,—as both consider the two genera as identical. It is when we proceed to compare the inside of the ventral valves in the two fossils that we soon find that the similarity is only an apparent one. The longitudinal median septum, which is very weak and thin in *Oldhamina*, is strong and prominent in *Pterophloios;* and the lateral septa, such a very characteristic feature on the inside of the ventral valve of *Oldhamina*, have nearly entirely disappeared in *Pterophloios*, only indistinct irregular furrows yet remaining. The difference is far greater if we compare the dorsal valves of the two fossils. It is true the dorsal valves of both fossils are concave, but beyond that the similarity ceases. It is solid and compact in *Pterophloios*, and cut up in many narrow lobes in *Oldhamina*, and thus the two valves need not be further compared.

Thus it is evident that *Oldhamina* and *Pterophloios*, though showing certain

points of similarity, are yet entirely different things. But also *Oldhamina* and *Lyttonia* are sufficiently different to consider them as forming different genera. Already the general appearance of the two fossils suggests such a distinction, not to speak of the spirally rolled-up expansions and the callosity in the cardinal part of the ventral valve of *Oldhamina*. I therefore think myself quite justified in proposing the generic name *Oldhamina* for these forms. I have chosen this name in honour of the former chief of the Geological Survey of India, under whose direction I executed my geological studies in the Salt-range.

The genus has up to the present not been observed in any part of the world but in the Salt-range; and it is there represented by a single species, *Oldham. decipiens*, Koninck, sp.

1. Oldhamina decipiens, Koninck, sp., Pl. XXXI, figs. 1-9.

1863. *Bellerophon decipiens*, Koninck: Quart. Journ. Geol. Soc., Lond., Vol. XIX, p. 8, Pl. III, fig. 1.
1863. *Bellerophon decipiens*, Koninck: Fossiles paléozoiques de l'Inde, p. 15, Pl. III, fig. 1.

The general form of the shell is mostly more or less irregularly hemispherical, sometimes more elongate, sometimes broader. The larger or ventral valve is generally very strongly convex, chiefly in large full-grown specimens; and the smaller or dorsal valve is as strongly concave as the other is convex, so that there remains only a very small space between the two. Young specimens up to a longitudinal diameter of about 30 mm. are attached for a more or less extended space in the cardinal region. Full-grown specimens, however, are nearly always free, and only when they have been attached during their youth to very small bodies—for instance, to the shell of a small *Productus*, &c.—does this remain adhering in later stages of growth.

The shell is entirely without ornamentation, only covered by tolerably numerous, not very conspicuous, imbricating quite concentric striæ of growth, which are more numerous near the margin of the shell than in the middle. Only in internal casts is the singular structure uncovered, which led Mons. de Koninck to consider these fossils as Bellerophonts. This singular structure is caused by the septa on the inside of the ventral valve. There is first one thin median longitudinal septum, which is generally not quite straight but somewhat wavering in its direction, and is never very strongly developed, often entirely absent for a certain distance from the frontal margin. It is mostly bifid from about the middle of the length of the shell, bearing a furrow on its crest which becomes more and more broad as it approaches the frontal margin. By far more conspicuous are the lateral stepa, of which 12 to 16 can be counted on each side of the median one. On the internal cast they appear as shallow furrows, in which always part of the shell remains. If, however, the inside of the valve be accessible to view, which never is the case except when effected artificially, these lateral septa appear as high sharp crests, overhanging towards the frontal part of the shell and forming

with the median longitudinal septum an angle of about 40 degrees. They do not, however, originate immediately at this latter septum, but are separated from it on both sides by a more or less broad smooth zone. Though the resemblance of these lateral septa to those occurring in *Lyttonia* is very great, yet there exist also in this respect very cardinal differences between the two genera. Whilst they are vertical and arranged in right angles to the median septum in *Lyttonia*, they are strongly overhanging and forming a more or less acute angle with the median septum in *Oldhamina*.

The whole inside of the valve between the lateral septa as well as on the smooth zones along the median septum is covered with innumerable small elongated grooves, which follow everywhere the direction of the longitudinal extension of the shell.

The inside of the cardinal region of this valve is very characteristic, but rather difficult to understand. There are two well-developed, strongly diverging, ridge-like hinge-teeth projecting from the top of the first pair of lateral septa. The muscular scars, so prominent a feature in *Lyttonia*, are nearly absent in *Oldhamina*, and only indicated by faint prominent lines, which originate between the upper termination of the hinge-teeth and reach down to the commencement of the second and third pairs of lateral septa. The median longitudinal septum reaches up directly to the short, straight, notch-like hinge-line, where it terminates in a slight swelling, which is indistinctly bipartite.

The dorsal valve has never been observed by me in an entire state, always only more or less considerable fragments having been found. But in by far the greater number of specimens of this species the dorsal valve is still preserved inside the ventral one, and thus, in etching such a specimen, the whole dorsal valve may be observed, though it falls to pieces as soon as the rock is removed, but during the process of exposing the valve, the entire shape of it may be well studied, and it was in this manner that the drawing, Pl. XXXI, fig. 4 *b*., was traced.

The substance of this valve is very thin, nearly as thin as paper. Externally it is very distinctly and densely papillate. Along the solid middle piece extends a well-marked but not angular furrow. Laterally it is divided in long narrow lobes by deep incisions which commence at the solid middle piece and reach to the very margin of the valve, no continuous border being present. These incisions are sometimes interrupted and bridged over by shelly substance. The inside of the valve is in general very much like that in *Lyttonia*. A tolerably strong median longitudinal septum extends along the middle of the solid middle piece, and the incisions are surrounded by rather high angular margins, which I take to form part of the brachial apparatus. Otherwise the inside of the valve appears entirely smooth to the naked eye. Under the lens, however, all specimens show a very fine papillation also on the inside, and sometimes one can observe at the same time a fine striation, not dissimilar to striæ of growth, forming curved lines, which are directed with their convex side towards the margins of the valve.

The hingeline of this valve is not quite straight, but somewhat roof-shaped, the low triangular process in the middle corresponding to a shallow triangular recess under the hingeline in the ventral valve. The cardinal process of the dorsal valve reaches up to the end of the triangular prominence. The greatest height of this process is, however, not situated at the end, but at a certain distance from it. It is composed of four vertical lamellæ, which have a somewhat triangular shape, with one corner of the triangle directed towards the interior of the shell. On both sides of the cardinal process along the hingeline there extend for a short distance smooth triangular spaces. These are followed by high sharp crests, which originate near the point where the cardinal process is highest and extend in a sloping direction towards the margin of the shell, uniting with the first pair of prominent ridges corresponding to the ridges surrounding the incisions of the shell further outside. Between these sloping ridges just described and the hingeline triangular grooves are formed, which serve for the reception of the cardinal teeth of the ventral valve. The cardinal process is in direct continuation with the longitudinal septum, which extends over the whole inside of this dorsal valve. Of muscular impressions, &c., nothing can be observed.

The measurements are not of great importance in this species. Nevertheless I shall give here the dimensions of some specimens, according to the rule which I have adopted in this whole work. Of these specimens Nos. I and II are from Chidru and No. III from Jabi. Their measurements are as follow :—

	I.	II.	III.
Entire length of the shell	48 mm.	53 mm.	55 mm.
„ breadth „	46 „	45 „	44 „
Breadth of the lateral wings in the cardinal region .	23 „	?	28 „
Entire thickness (inflation) of the shell . . .	35 „	32 mm.	33 „

No larger specimens have been observed up to the present.

Locality and geological position.—This species begins already in the middle division of the Productus-limestone, but seems not to be common there. It is much more numerous in the upper division, where it has been found in more or less great numbers. It has been collected in the middle Productus-limestone by myself at Katta in the thick, compact, silicious limestones forming there that division (one specimen), and on the road between Vurcha and Uchâli (two specimens, one ventral and one dorsal valve), another specimen was collected at the same locality by the Native Mogul; lastly, a specimen of this species was found in the same division at Swás by Dr. Oldham.

In the upper division of the Productus-limestone the species has been found by myself in the Cephalopoda bed at Jabi (two ventral and one dorsal valve), and in the same bed at Chidru (seven ventral and two dorsal valves), then in the section near Kufri (one specimen), and in the mountains east of Katwâhi (one specimen). By Mr. Wynne the species has been collected in the Chittawán (one specimen) and Trans-Indus at Bilot (one specimen). By myself it has been found Trans-Indus also at Káfirkot (one specimen).

Remarks.—This species is one of the most remarkable occurring in the Salt-range, and it is chiefly through it that I was able to classify all the allied forms among the *Thecideidæ*. It was the inside figure of *Lyttonia* which led to a comparison with the dorsal valve of *Pterophloios*, and it was, on the other hand, the external appearance of this species which led to the detection of the ventral valve of *Pterophloios*. From this chain of observations it appears to be most clear that the shells here under consideration must stand in a more or less intimate connection with *Pterophloios*, and thus also with the *Thecideidæ* in general; and I hope that from the descriptions I have given this view will be found to be the right one. That, nevertheless, *Oldhamina* is very far different from *Pterophloios*, I have indicated already in the description of the genus *Oldhamina*.

Of other forms none is known to me which could in the least be compared to the present species; especially are all the intermediate forms between *Oldhamina* and *Pterophloios* quite unknown up to the present. There is yet a wide field of discovery in this direction.

Family: *RHYNCHONELLIDÆ*.

This is one of the best circumscribed families of the *Brachiopoda*, and there are only very few genera the position of which in this family remains doubtful.

The characters of the family are very well known, and it appears barely necessary to repeat them here once more. Less so are the genera belonging to it; and there is but very little doubt that if the interior of the different shells were better known, a greater number of well-defined genera would be distinguishable in this family also as well as in the *Terebratulidæ* and the *Spiriferidæ*.

As it is, there can be distinguished at once three large groups of forms among the shells belonging to the family. The first is characterised by a very insignificant development of internal septa. In the ventral valve generally only dental plates are present, which do not unite in the middle line, and in the dorsal valve a not very conspicuous median septum is developed.

In a second group of forms the internal septa are much more strongly developed and have gained much in extent. The dental plates converge towards the middle and form also in the ventral valve a more or less extended median septum. The septum in the dorsal valve is also generally rather large and high, and bears often at its upper end shelly expansions.

In the third group at last the internal septa have reached their maximum of development. The whole inside of the shell is divided by them more or less distinctly into five chambers, one median, marked off by the dental plates of the ventral valve, and the lateral expansions of two septa in the dorsal valve, and two lateral chambers outside of the median septa in both valves.

Into these three groups can be brought very naturally all the forms that have

been made known up to the present, and they can very conveniently be considered as sub-families. The first of these groups is typified in the genus *Rhynchonella*, and therefore most conveniently the sub-family will bear the name of RHYNCHONELLINÆ. Within the second group the group characters are most distinctly brought out by the genus *Camerophoria*, and thus I shall call the second sub-family CAMEROPHORIINÆ. The third group is typified by the genus *Pentamerus*, and therefore will have to bear the name PENTAMERINÆ.

All these three sub-families agree in one essential point, which is, that if there be a distinct free brachial apparatus at all developed, it consists of two diverging, curved, horn-shaped crura, which are fixed to the cardinal part of the dorsal valve, the hingeplate in the same valve being deeply cut open in the middle.

Already by former authors there has been felt a necessity of dividing the great number of forms belonging to the family *Rynchonellidæ* into several groups, but the endeavour to do so has mostly resulted in the spliting up of the family into several new families, as, for instance, is shown by Dall's excellent catalogue of the names applied to Brachiopoda, in which the old family *Rhynchonellidæ* is split into a family of *Pentameridæ* and one of *Rhynchonellidæ*. However clearly it is shown by such endeavours that there are collected in the family forms which require a more special grouping, yet I do not think it advisable to distribute these shells, which are all linked together by a similar development of the horn-shaped crura and the tendency to develope more and more strong partitions within their shells, into quite distinct families; it is, I think, much more practical to distinguish sub-families as I have indicated above.

If we pass in review the principal genera that belong to each sub-family, we find that the single genera must be distributed in the following manner :—

Sub-family : *RHYNCHONELLINÆ.*

The partitions in the interior of the valves of the forms belonging to this sub-family are either entirely absent, or not very strongly developed. They are entirely absent only in a genus which has been detected by me in the Salt-range, and which will bear the name

TEREBRATULOIDEA, Waagen, n. gen. The shells belonging to this genus are not very rare in the Salt-range, and have been described by Davidson as *Rhynchonella pleurodon*, Phill.

Next in the series comes the genus

RHYNCHOTREMA, Hall: 1860 (Thirteenth Regent's Report, New York State Cabinet, p. 68). When working out the palæontology of the *Rhynchonellidæ*, Hall unfortunately was not acquainted with the typical species of the genus *Rhynchonella*, and therefrom resulted several errors which would not have occurred had specimens of *Rhynch. loxia* been at his disposal. The genus *Rhynchotrema* is, however, excepted from these errors, and can very well be retained. The character which

deserves the greatest consideration is, however, not the strange development of the deltidial pieces of the ventral valve, but the absence of dental plates in the same valve. This character is of the greatest importance, and may serve to distinguish the genus readily. But then, if we take this character to be the distinguishing one, and we are justified in doing so as it is also present in the typical species, there are yet a number of forms in the older deposits which fall within the range of the genus. There is foremost the beautiful *Rhynch. speciosa*, Hall, and its allies from the Oriskany sandstone which will have to be considered as a *Rhynchotrema*. The deltidial pieces are very little developed in these species or even absent, but this, I think, is of minor importance in comparison with the fact that the dental plates are absent. In this character these large species agree with the typical *Rhynchotrema increbescens*, Hall; and it appears to me that they can well be considered as forming part of the same genus.

Thus defined, the genus *Rhynchotrema* is chiefly represented in the silurian and devonian periods, but whether there exist yet more recent representatives of it remains doubtful.

Rhynchonella, Fischer: 1809 (Notice sur les Foss. d. Gouv. d. Moscou, p. 35, pl. II, figs. 5, 6; *Stenoschisma* (Con.), Hall; *Leiorhynchus*, Hall). This genus is characterised by strong dental plates in the ventral and a tolerably strong median septum in the dorsal valve.

The true *Rhynchonellæ* begin beyond doubt already in the silurian period, and from there extend up through all formations. Their number is very large, and the distinction of the several species extremely difficult. Therefore it seems almost necessary to introduce yet further sub-divisions, and as such, which can very easily be distinguished, the groups separated by Bayle and d'Orbigny from the great mass of forms under the names of *Uncinulus*, Bayle, and *Acanthothyris*, Orb., will have to be considered, and will probably best be retained; chiefly the latter on account of the strange development of the dorsal septum and the curra. The name "Wilsonia" introduced by Quenstedt for *Uncinulus*, I cannot consider as a generic name formed after the rules of nomenclature.

In the jurassic formation species beginto appear in which the septum of the dorsal valve is very little developed or even entirely absent. For these forms, perhaps, the name of Cyclothyris, M'Coy (or as is advocated by Dall, *Hypothyris*, Phill.?), might be retained. I have, however, not sufficient materials at hand to give a positive opinion on this point.

Hemithyris, Orb., Bronn: 1847 1848 (Ann. Sci. Nat., VIII, p. 246; Bronn's Jahrb., 1848, p. 246). This may form apparently also a distinct generic group on account of the nearly absent deltidial plates and not very strongly developed septum. Species belonging to it occur chiefly in the tertiary and recent periods, but the genus begins already during cretaceous times.

Rhynchopora, King: 1856 (Ann. Mag. Nat. Hist., 2nd Ser., Vol. XVII, p. 506). This genus seems to have the interior stucture of Rhynchonella, but its shell is coarsely punctate; permian and carboniferous periods.

EATONIA, Hall: 1869 (Twelfth Regent's Report, New York State Cabinet, p. 35). Very nearly related to *Rhynchotrema*. Also no dental plates in the ventral valve, a strong median septum in the dorsal valve, with four curved crura instead of two; upper silurian (Lower Helderberg), and lower devonian (Oriskany).

DIMERELLA, Zittel: 1870 (Palæontographica, Vol. XVIII, p. 220). This and the next genus belong to a group which deviate in their general outward appearance considerably from the other forms belonging to the sub-family by the existence of a large area in the ventral valve, and approach in this respect the *Spiriferidæ*. This genus is besides characterised by a very high and long dorsal septum; trias.

RHYNCHONELLINA, Gemmellaro: 1878 (Studj. Pal. sulla Fauna del Calcare a Ter. janitor, III, p. 29). Shell with a large area, a straight hingeline, the dorsal valve interiorly with very long sometimes bifid crura; upper jurassic.

With these eight to twelve genera I consider the forms composing the sub-family *Rhynchonellinæ* exhausted.

The next sub-family is the

Sub-Family: *CAMEROPHORIINÆ.*

This sub-family is characterised by the much stronger development attained by the internal partitions in the valves of the shells belonging to it. In the ventral valve the dental plates are oblique, and unite for a greater or less distance, forming a kind of septum along the middle line of the ventral valve. In the dorsal valve either the crura are supported by septa, which mostly unite to form a median septum, or the median septum bears lateral expansions at its upper end.

The number of genera belonging to this sub-family is not large; there are not known to me more than three which I should like to subsume in this sub-family. The one which is best known is

CAMEROPHORIA, King: 1846 (Ann. and Mag. Nat. Hist., Vol. XVIII, pp. 89-91; *Stenoschisma* (Conr.), Dall: Bull. Unit. St. Nat. Mus. Nr., 8). The internal structure of this genus is very well known from the excellent figures and description by King as well as by Davidson. It commenced, it seems, already in silurian times, and extended up to the permian period, but above the permian strata it has not yet been observed, so far as is known to me.

STRICKLANDIA, Billings: 1859 (Canadian Naturalist, IV, April, p. 132). In the ventral valve the dental plates form a small chamber, in the dorsal one the crura are free for their greater extent, only fixed quite near their origin to short septal plates, which do not unite to form a median septum; externally the ventral valve with a more or less large area; silurian.

CAMERELLA, Billings: 1859 (Canadian Naturalist, IV., p. 301). In the ventral valve the dental plates form a small chamber below the beak; in the dorsal valve the crura are fixed to two strong septal plates which unite to form a very long and strong median septum; silurian.

The last sub-family is typified by the genus *Pentamerus*, and will bear the name of

Sub-family : *PENTAMERINÆ.*

This sub-family is not represented in the Salt-range. It is chiefly developed in the silurian and devonian epochs, and comprises the following genera :—

PENTAMERUS, Sow. : 1813 (Min. Conch., Pl. 28, fig. 1 ; *Antirhynchonella,* Quenst. ; Petrefaktenk. Deutschl., II, 231).

GYPIDIA, Dalmann : 1828 (Kongl. Vetensk. Acad. Handl., 1827, pp. 93-100. ? *Conchidium,* Linné).

GYPIDULA, Hall : 1867 (Pal. New York, IV, pp. 373-380).

PANTAMERELLA, Hall : 1867 (Pal. New York, IV, pp. 373-375).

BRACHYMERUS, Shaler : 1865 (Bull. Mus. Comp. Zool., I, p. 69 ; *Anastrophia,* Hall).

Of the whole family *Rhynchonellidæ* only the first two sub-families are represented in the palæozoic deposits of the Salt-range. Of the *Rhynchonellinæ* three genera occur, *viz.*, *Terebratuloidea*, W. ; *Uncinulus*, Bayle ; and *Rhynchonella*, Fisch. The *Camerophoriinæ* are represented by the single genus *Camerophoria*, King.

As regards the developement in time of the *Rhynchonellidæ*, no distinct law can be made out. It seems that we are yet too little acquainted with the details of the interior of these shells to get at a right understanding of the plan of development they have followed.

I.—Sub-family : *RHYNCHONELLINÆ.*

Genus : TEREBRATULOIDEA, Waagen, n. gen.

1852. *Rhynchonella* (Fisch.), Davidson : Quart. Jour. Geol. Soc., Lond., Vol. XVIII, p. 29.

It was only after long and continued painstaking that I arrived at a satisfactory determination of the shells here described under the head of *Terebratuloidea.*

When examining the shells more or less similar exteriorly to *Rhynchonella*, I was struck by the circumstance that the specimens which were identical with what had been determined by Davidson as *Rhynchonella pleurodon*, Phill., never possessed an entire beak, but that the beak was always truncated and pierced at its end by a large round foramen. Other *Rhynchonellæ*, as, for instance, those of the group of *Rh. wilsoni*, and all the *Camerophoriæ*, never showed such a truncation of the beak. Taking this truncation to be naturally present and not caused by a strange kind of preservation, this peculiarity and the general form of these shells led me first to compare them with *Trematospira*, Hall. I spent weeks in the vain endeavour to detect the spirals, but I never succeeded. In all the specimens which I had occasion to study I found only two curved horn-shaped crura proceeding from a hinge-plate, which was deeply cut open in the middle. I thus, though reluctantly, was compelled to consider these strange shells as forming part of the *Rhynchonellidæ.*

It was only natural that Mr. Davidson, seeing the great general resemblance of these fossils to *Rhynchonella pleurodon*, and having but one or two specimens at his

disposal, took the truncation of the beak to be only an accidental character, and thus united the shells with Phillips's species. With a greater number of these fossils before one it is very observable how in the truncation of the beak they deviate in every case from other species of *Rhynchonella* occurring in the same beds; one must then be struck by this peculiarity, and must recognise that it is not by accident that this truncation came to be formed. If one then further observes that this external character of a truncated beak goes hand in hand with internal peculiarities of great importance, one must come to the conclusion that this form deviates sufficiently from the general type of *Rhynchonella* to warrant its distinction under a proper generic designation.

Led by such considerations I have ventured to propose the name of *Terebratuloidea* for these shells, which genus may be characterised in the following manner:—

Shell more or less transversely oval or rounded, in its general appearance *Rhynchonelloid*, with strongly plaited valves and a high median fold in the dorsal and a corresponding sinus in the ventral valve. Hingeline curved, beak truncated with a terminal round foramen; deltidium formed of two distinct plates, which limit the foramen below only for a very short distance.

Internally, the ventral valve with two strong hinge-teeth, which are, however, not supported by dental plates. The dorsal valve bears a tolerably large triangular hinge-plate, which is united on both sides by the deep dental sockets, and is triangularly cut open in the middle up to the very apex of the valve, which also is a little cut out. There is no cardinal process. On both sides of the median incision very short curved crura take their origin, and proceed for a short distance in a slightly diverging direction towards the interior of the shell. There is no median dorsal septum.

The muscular and vascular impressions are not sufficiently distinctly visible to be described accurately.

From this short description it will be already sufficiently clear what great differences exist between the true *Rhynchonella* and the shells contained in the present genus. All the internal partitions, which are characteristic for *Rhynchonella*, the dental plates as well as the dorsal septum, are absent in *Terebratuloidea*. Externally the truncation of the beak is a very characteristic feature, but nevertheless this truncation has puzzled me a great deal. The foramen by which the beak is truncated is in some cases so very large that it is evidently impossible it can have been originally so; it must have attained such a size by the breaking away of parts of the shell. But if in some cases the truncation has partly been caused by an injury the shell has received, it may be questioned if the truncation is not in all cases only a secondary feature and due to the mode of preservation of these shells. I cannot positively assert that the beak has never had the shape of the beak of *Rhynchonella*, but I can most positively say that I have never seen a specimen in which the beak was not truncated. Whether, how-

ever, the beak was originally truncated, or whether it has become so only in the process of fossilisation, the truncation is in every case in intimate connection with the internal structure of the shell. In all the genera of the *Rhynchonellidæ*, in which dental places are present, if the beak be broken or injured in any way, a large round foramen can never be formed, the dental plates being an impediment to this; and it can always be easily made out that the beak has been broken or injured. The case is different in the present fossils. No dental plates are present, and so long as the injury the beak has received is within reasonable dimensions, a round foramen will always be produced. It is difficult, then, to state whether this has been due to an injury the beak has received, or whether it is an original feature. Nevertheless, I should be inclined to think that a slight truncation was originally present; for instance, fig. 1, Pl. XXXIII, shows the beak in its natural condition.

Of other genera, *Rhynchotrema*, Hall, must be chiefly compared. I was long time in doubt whether the shells here under consideration should not be considered as belonging to Hall's genus, and only after I was enabled, through the great kindness of Mons. Barrande, to examine the "Regents' Reports of the New York State Cabinet," a publication which is extremely rare in Europe, I became satisfied that the two genera were different. In *Rhynchotrema* no dental plates are present in the ventral valve, and with this deficiency a partial truncation of the beak also appears, which peculiarity is already expressed in the name. So far the Indian shells would well be comparable to *Rhynchotrema*, but if we take the dorsal valves into consideration, we find that in Hall's genus a very long and strong median septum is present, whilst the Indian shells are devoid of such a septum. This difference is, I think, sufficient to distinguish generally between the two groups.

Of other genera none is so nearly related as to require special comparison.

In the Salt-range the genus is represented by four species, which probably are in close developmental connection. The geologically oldest species is *Terebratuloidea minor*, Waagen. It occurs in the lower division and the lower parts of the middle division of the Productus-limestone; it is a moderately inflated form of rather small dimensions.

In the lowest beds of the middle division of the Productus-limestone another species occurs, which is very nearly related to *Terebratulodea minor*, and is chiefly only distinct by a very regular concentric sculpturing which covers both valves. This species will bear the name of *Terebratuloidea ornata*, Waagen.

In the upper region of the middle division of the Productus-limestone two species can be distinguished: one is tolerably large and very strongly inflated, and will bear the name of *Terebratuloidea davidsoni*, Waagen; the other remains smaller and is always flat, and therefore will be called *Terebratuloidea depressa*, Waagen. In the upper division of the Productus-limestone the genus becomes already extinct.

Up to the present the genus *Terebratuloidea* has not been observed in any

other part of the world; but there is a possibility that either among the species of *Rhynchonella* or among those of *Trematospira* some species may have been described which, if the interior were known, would prove to belong to *Terebratuloidea*. For instance, the shell which has been described by Hall under the name *Trematospira gibbosa*, from the Hamilton group, bears in its external appearance a very great resemblance to my species of *Terebratuloidea*. The spirals have not been detected in this species, and there is thus the possibility of its belonging to the Indian genus. Another species, which very probably belongs to the genus, is the shell that has been figured and described by Toula from the upper carboniferous limestone (coal measures) of Cochabamba in the Andes under the name of *Rhynchonella pleurodon*, Phill. In the description a constant truncation of the beak is mentioned, and also the figure shows this truncation excellently.

As the case stands, nothing certain can be said about the geological range and the geographical distribution of the genus *Terebratuloidea*.

1. TEREBRATULOIDEA DAVIDSONI, Waagen, n. gen. et sp., Pl. XXXIII, figs. 1-5.

1862. *Rhynchonella pleurodon* (Phill.), Davidson: Quart. Journ. Geol. Soc., Lond., Vol. XVIII, p. 29.
1863. *Rhynchonella pleurodon* (Phill. Davids.), Koninck: Fossiles paléozoiques de l'Inde, p. 36.

The general form of this shell is more or less globose, with very inflated valves, a large median fold in the smaller and a corresponding sinus in the larger valve. The front is truncated, the beak little produced, truncated; the whole shell covered by sharp high folds.

In a dorsal aspect of the shell it appears always broader than it is long, and often this is very considerably the case. Both valves are about equally strongly vaulted, but in a lateral view the ventral valve appears to be flatter than the dorsal one. This is caused by the circumstance that the lateral lobes of the ventral valve descend in a but little curved line to very near the front, and then are rather suddenly deflected to meet the lateral lobes of the dorsal valve. The median part of the ventral valve, however, bends in a very regular strong curve to form the median sinus of this valve.

The beak is not very prominent, tolerably thick, well bent over and more or less firmly appressed to the apical part of the dorsal valve, whereby the deltidial plates are mostly quite concealed. It is truncated and pierced at its extremity by a rather large round foramen. On both sides of the foramen extends a rather large sloping false area.

The whole valve is covered by strong angular ribs, which commence at the margin of the foramen and are highest in the frontal region. There are generally four ribs on the lateral wings, and two to three in the median sinus. The frontal part of the valve is strongly truncated and covered by very numerous imbricating striæ of growth.

When the dorsal valve is removed and one can observe the internal side of the ventral valve, the large deltidial plates surrounding the foramen at its lower side are exposed. Where the deltidial plates terminate there are on both sides very thick and strong nearly globular hinge-teeth, which are separated from the external side of the valve by a deep but narrow furrow. On the lower side these teeth terminate in a high sharp crest which turns round towards the extremity of the beak and then descends to the bottom of the valve. By these crests running down on each side a semicircular place is marked off in the region of the beak. In the middle this semicircle is broken through by two slightly-raised lines, which surround a somewhat deepened oval space and unite further up towards the beak. How far these impressions may be taken to be muscular scars I cannot make out, as the inside of the valves I have been able to study is too coarsely preserved to allow of a quite accurate observation in this respect.

The dorsal valve appears generally more strongly curved than the ventral one. Its arch begins at the very apex of the valve, and from there extends in nearly a semicircle to the frontal region. The curvature is nearly the same in the median and the lateral lobes. In the frontal region this valve is as much truncated as the other one, and bears also a great number of imbricating striæ of growth crowded together. This valve also is covered by very strong angular ribs, which take their origin not quite at the apex but a short distance from it, so that the apex itself remains smooth. This smooth part of the valve is, however, nearly always concealed below the beak of the ventral valve. The number of ribs is mostly four on the median, and four on each lateral part of the valve, but sometimes only three ribs occur on the middle part.

The inside of this valve is highly characteristic. The apex is strongly bent in, very pointed, and without a cardinal process. The extremity of the apex is slightly cut out, so as almost to form a visceral foramen. From this emargination an angular slit extends, which begins in an acute angle at the apex, becomes more and more broad, and divides the hinge-plate into two parts. The slit is hemmed in on both sides by raised shelly margins, the slightly bent-up inner margins of the crura. On their external side the crura are united to the hinge-plate only for a short distance, not so far as the dental grooves extend. The crura themselves are very short, flat, shelly plates, only provided on their inner side with a slightly-thickened and raised margin, but very little bent. They are separated from the dental grooves by a narrow, triangular, flat space of hinge-plate. The dental grooves extend along the cardinal margin of the shell as narrow, deep, triangular, slit-like pits. In the bottom of the valve, several raised lines and deepened places can be recognised, but not a trace of a median septum. Two narrow elongated grooves are chiefly conspicuous, extending in divergent directions a little distant from the middle line, and accompanied on their inner side by a slightly-raised line. In the drawing, Pl. XXXIII, fig. 3, they extend somewhat too far up towards the cardinal region. They are probably the impressions of the adductors. About in the middle of the

longitudinal extension of these impressions there starts on both sides a semicircular line, which reaches the margin of the shell.

The species never attains considerable dimensions, and the specimen figured on Pl. XXXIII, fig. 1, is the largest that has been observed by me. Young shells also exhibit inflated valves, and can easily be recognised by this feature. The truncation of the frontal part, however, is only developed when the shell is full grown.

The dimensions of three specimens from Musakheyl are as follow:—

	I.	II.	III.
Entire breadth of the shell	23 mm.	22 mm.	19 mm.
„ length „	21 „	16·5 „	16 „
„ thickness of both valves	18 „	18 „	15 „
Apical angle of the ventral valve	97°	107°	98°
„ „ „ dorsal valve	115°	115°	103°

Locality and geological position.—The species is characteristic of the middle division of the Productus-limestone and chiefly for the upper part of it. It has been collected in this position by Dr. H. Warth, Mr. Theobald, and myself at Musakheyl (eight specimens), by Mr. Wynne at Morah (seven specimens), by myself in the coral beds at Virgal (three specimens), in the mountains east of Katwàhi (three specimens), in the Chittawán (one specimen), and in the section at Khura in the top beds at the calcareous series (one specimen). This is the geologically youngest specimen that has been obtained by me.

Remarks.—This species has been identified by Mr. Davidson with *Rhynchonella pleurodon*, Phill., and it requires a special explanation why I cannot agree in this respect with Mr. Davidson. I had for comparison quite a number of specimens from Visé, and several specimens from the Gailthaler Schiefer; also, through the great kindness of Mons. de Koninck, a number of specimens from Settle in Yorkshire, from Drépence (Belgium) and from Tournais. The specimens from Visé and the other northern localities (except Tournais) agree exactly with the typical form of *Rhynch. pleurodon*, whilst the specimens from Gailthal are more finely plicated. If we compare only the external form of the Indian specimens with those from Visé and Settle, we find already marked differences. The number of ribs that generally occur is different in the two species. Full-grown specimens of *Rhynch. pleurodon* have always at least five ribs on the median fold, and often a greater number. Only young specimens sometimes bear three or four ribs on the median fold, and even this seems to be rarely the case, as among the lot I have for comparison there is only a single specimen with four ribs on the median fold. In the Indian species, on the contrary, four ribs is the maximum number that occurs, and frequently only three ribs. Another very marked difference consists in the truncated condition of the frontal parts of the Indian shells. Such a truncation I never observed in any specimen of *Rhynch. pleurodon;* and indeed in the description by Davidson it is not indicated as ever occurring in the species. A further character, which is not mentioned in any description, but which is very strikingly developed in *all* the specimens

of *Rhynch. pleurodon* I have obtained for comparison, is the impressed condition of the cardinal part of the dorsal valve, which apparently is in connection with the development of a strong internal septum. This character also is absent in the Indian species.

If we turn now to the internal characters, these are decidedly peculiar in the Indian shells, but it has to be ascertained whether similar characters are present in *Rhynch. pleurodon*. There are among the materials sent to me by Mons. de Koninck three specimens from Settle and four specimens from Drépence, in which the internal characters can be well observed. Chiefly one specimen from Settle is beautiful in this respect. It is an internal cast exhibiting clearly two very strong and long dental plates, which approach each other closely towards the extremity of the beak. In the dorsal valve a very strong and long median septum is present. The cardinal teeth in the ventral valve are long, high, narrow ridges. In the Hof-Mineralien Cabinet at Vienna there is a specimen from Tournais of a very nearly allied form, which is, however, also generally considered to belong to *Rhynch. pleurodon;* the internal apparatus can be well seen. It is not an internal cast but a hollow specimen. It exhibits a high and long dorsal septum and tolerably short curved crura. The dental plates are partly covered up. Mons. de Koninck informs me that he considers the specimens from Tournais not to belong to *Rhynch. pleurodon* but to a different species. I perfectly concur in this respect with the celebrated Belgian palæontologist, as the Tournais specimens can be distinguished from *Rhynch. pleurodon* by a small but very sharply defined area. From this it appears that not only the typical form of *Rhynch. pleurodon*, but also the allied shells, have an internal structure entirely different from *Terebratuloidea davidsoni*, and I thus think myself justified when I consider shells so entirely different in internal structure as not belonging to one and the same species.

Of other forms none seems to be very nearly related to the present species, except the Indian shells, which I shall describe presently.

2. Terebratuloidea depressa, Waagen., n. gen. et sp., Pl. XXXIII, figs. 6, 7, 8.

The general form of this species is transversely oval in full-grown specimens, and more round in young ones. The valves are flat, depressed, the beak more or less prominent, truncated. There is a median fold in the dorsal, and a corresponding sinus in the ventral valve. Both valves are covered by sharp angular ribs.

The ventral valve is nearly quite flat, only curved in the apical region and where the sinus is sunk in, the lateral lobes being nearly straight towards the front. The beak is but little bent over, prominent and not appressed to the dorsal valve. It is pierced at its apex by a not very large circular foramen. This is limited on its lower side by very distinctly developed deltidial plates. On both sides of the deltidium narrow, sloping, flat spaces extend, forming a small indistinct false area.

The folds which cover the valve do not commence immediately at the margin

of the foramen, but at a little distance from it, and are highest in the frontal region. Generally they do not bifurcate, but exceptionally such a bifurcation takes place. The number is very regularly three in the sinus and four on each lateral part.

The dorsal valve is slightly more vaulted than the ventral one, its curvature being nearly equal for its whole length. The ribs developed on this valve do not commence immediately at the apex but at a short distance from it. There are very regularly four ribs on the median fold; on the lateral parts, however, there are sometimes three, sometimes four ribs.

It was not possible to ascertain the internal characters in this species, as there are only very few specimens, and none could be sacrificed for the purpose. I have put this species into the genus *Terebratuloidea* on account of its general resemblance to *Terebratuloidea davidsoni*, and because the beak is very distinctly truncated, by which character it is apparent that the ventral valve possessed no dental plates inside.

The measurements of two specimens from Musakheyl are as follow: —

	I.	II.
Entire length of the shell	16 mm.	15 mm.
„ breadth „	20 „	16 „
„ thickness of both valves	9 „	8 „
Apical angle of the ventral valve	95°	82°
„ „ „ dorsal valve	114°	98°

Locality and geological position.—There are altogether only five specimens of this species known to me, which all five were collected by Dr. H. Warth at Musakheyl in the upper region of the middle division of the Productus-limestone.

Remarks.—This species seems to be a rather rare one, as neither Mr. Wynne nor myself have met with it, and as only the more lengthened enquiries of Dr. Warth have brought to light some specimens.

It is rather closely related to *Terebratuloidea davidsoni*, with which it occurs, but can be distinguished from that species by its depressed form, its sharp, not truncated, front-line, and the prominent beak.

Of European species certain varieties of *Rhynch. pleurodon*, Phill., must be compared. It is, however, necessary to compare specimens of an equal size of the two species, when we will find one very striking character which makes a distinction between the two not difficult. This is, that in *Rhyuch. pleurodon* the beak is always very small, pointed, and not prominent, whilst it is comparatively large, prominent, and truncated in *Terebratuloidea depressa*. This, together with the presumable internal differences, does, I think, well justify the distinction of the two as distinct species.

3. Terebratuloidea minor, Waagen, n. gen. et sp., Pl. XXXIII., figs. 11, 12.

The general outline of this shell is more or less transversely oval, its valves are

moderately inflated and covered with strong angular ribs. The shell never attains considerable dimensions.

The ventral valve is very little vaulted, nearly flat, its curvature being chiefly limited to the middle part where the sinus is developed, and to the apical part. The beak is strongly prominent, well bent over, and when entirely preserved tolerably long. It is pierced at its extremity by a rather small round foramen, which is limited at its lower side by large conspicuous deltidial plates, owing to the beak being quite free and not appressed to the apical part of the dorsal valve.

The whole valve is covered by strong radiating ribs, of which two are in the sinus and three to four on each lateral part. The ribs commence at a little distance from the extremity of the beak, and are highest in the frontal region.

On both sides of the beak a smooth, sloping, triangular space extends along the hinge-line, forming a not very conspicuous false area.

The dorsal valve is considerably more strongly vaulted than the ventral one. The apical region is smooth, but a short distance from it the ribs commence and grow quickly stronger as they approach the front of the shell. There are very regularly three ribs on the median fold, and two to three on the lateral parts of this valve.

The dorsal valve as well as the ventral one is covered by distant imbricating striæ of growth, of which sometimes two are at the frontal margin, thus causing an indistinct truncation of the front. This is, however, not a constant character, but only a transitional stage in the progress of growth of the shell.

The internal characters of this species could not be entirely ascertained, as the majority of specimens did not admit of investigation in this direction. In some specimens it could be made out with tolerable certainty that there are no dental plates in the ventral valve, but whether the dorsal valve possesses a septum could not be observed. From the general similarity of this species to *Terebratuloidea davidsoni*, and from the truncated condition of its beak with the foramen at its extremity, it can with tolerable certainty be concluded that the species belongs to the genus *Terebratuloidea*.

The dimensions of two specimens from Swás are as follow :—

	I.	II.
Entire length of the shell	14 mm.	12 mm.
„ breadth „	17 „	14 „
Thickness of both valves	11 „	8·5 „
Apical angle of the ventral valve	96°	84°
„ „ dorsal „	111°	107°

The specimen No. I is the largest that has been observed by me up to the present.

Locality and geological position.—This species is not so rare as the preceding one, but also not so common as *Terebratuloidea davidsoni*. It is a characteristic shell of the lower half of the middle division of the Productus-limestone, and thus geologically older than the two species described previously. The greatest number of speci-

mens was collected by Dr. Oldham at Swás, in a yellowish-grey marly limestone, the specimens not being silicified (eight specimens). By myself the species was collected in the Bazarwán (one specimen), at Nursingpahár in a black coaly limestone (three specimens), and at Katta in a yellow marly limestone (one specimen). At both the latter localities the specimens were met with in the very lowest beds of the middle Productus-limestone.

Remarks.—This species is very nearly related to *Terebratuloidea davidsoni*, and by most naturalists it will probably be considered as a variety of that shell. As it is, however, a variety in time, that is to say a mutation, I thought it well worthy of a proper designation. The most striking distinctive character between the two species is that the present species remains always much smaller than *Terebratuloidea davidsoni*. Specimens of an equal size of the two forms may be distinguished by the less strongly inflated valves, and the prominent not appressed beak of *Terebratuloidea minor*. Besides this the very regular occurrence of three ribs on the median fold of the dorsal valve is also worthy of notice.

Among European shells there is one very nearly related to the present species; this is *Rhynchonella davreuxiana*, Koninck. It is, however, very difficult to know what is really included under that name, as different authors consider very different shells to belong to this species. The original figure by Koninck represents a shell with extremely inflated valves, a very high and angularly prominent median fold, and ribs which commence only at a certain distance from the apex. That this figure is correct I conclude from a remark of Mons. de Koninck in his "Fossiles de Bleiberg," in which he states that he must retain the species *davreuxiana*, notwithstanding Mr. Davidson's having considered this name as a synonym of *Rh. pleurodon*. A chief difference, he says, between the two species consists in the ribs only commencing half way from the apex of the valves, and in their number being always three on the median fold. Also the constantly less considerable size is a very characteristic feature. From this I must conclude that Mr. Davidson has not quite rightly interpreted de Koninck's species, and that the figures in Davidson's work do not represent what is really denoted by the name *Rhynch. davreuxiana*. I may therefore be justified in distinguishing the Indian shell from *Rh. davreuxiana*, though it may be indentical or nearly identical with what Davidson has called by that name. There is one shell figured by Davidson under the above name, which is probably quite identical with the Indian specimens; this is the one from Shigar near Skardo, collected by Godwin-Austen and described by Davidson as *Rhynch. pleurodon*, Phill., var. *davreuxiana*, in the Quarterly Journal, Geological Soc., Lon., Vol. XXII, p. 36, pl. I, figs. 2, 3. Specimens of *Rhynch. davreuxiana* from Visé sent to me by Mons. de Koninck show all the distinctive characters from *Rhynch. pleurodon*, as indicated by that author. From *Terebratuloidea minor* the species can be distinguished by its extremely small and thin beak and the smooth apical region of both valves. Also in size it is smaller, and has a much more transversely oval general outline.

Of species which do not occur in Europe, *Rhynch. uta*, Marcou, must be compared. This species is chiefly allied to *Terebratuloidea minor* by its three sharp ribs on the median fold. It is distinct by its nearly quite smooth ventral valve, which is only plicated near the margins. *Rhynch. uta* has been described by Geinitz under the name of *Camerophoria globulina*, Phill. That the species is not a *Camerophoria* has been shown by Meek and Hayden, and from the internal cast of the ventral valve, as figured by these authors, it appears not quite improbable that it is a *Terebratuloidea*.

4. TEREBRATULOIDEA ORNATA, Waagen, n. gen. et. sp., Pl. XXXIII, figs. 9, 10.

The general outline of this shell is very much like that of the preceding species, transversely oval, only slightly broader than it is long. The valves are moderately inflated, the beak prominent, both valves bear strong radiating ribs. The whole surface of the shell is covered by a very neat concentric sculpturing.

The ventral valve is rather flat, only somewhat more strongly curved in the apical region. The beak is well bent over, prominent, not appressed, and truncated at its extremity by a tolerably small round foramen. The latter is limited on its lower side by very distinct, well-developed deltidial plates. On both sides of the beak extend smooth, sloping, triangular spaces, which form a kind of narrow false area. The whole valve is covered by strong radiating ribs, which commence at the margin of the foramen and are highest in the frontal region. Their number is variable, but never very large. There are generally one to two folds within the median sinus, and three to four on each lateral part. There are several more strongly-marked striæ of growth parallel to the margin on this valve, and some two or three of them are more closely approached to each other near the margin. But besides these striæ of growth there is also a very regular sculpturing over the whole surface of the valve; it consists of closely-placed, raised, concentric lines, which are not sharp on the top, and are separated from each other by shallow rounded furrows.

The dorsal valve is more strongly inflated than the ventral one; sometimes more, sometimes less strongly vaulted, and tolerably equally curved for its entire length. It is covered by strong radiating ribs, which begin almost at the apex, and soon grow very strong and high. They are variable in number, two to three on the median fold and generally four on the lateral parts. Concentric striæ of growth are observable also on this valve, but they are less strongly expressed than on the ventral valve, only near the margins of the valve two or three are more strongly marked. Besides these striæ of growth, there is on this valve also a very distinct concentric sculpturing, of narrow, rounded, raised lines, separated from each other also by narrow rounded furrows. On both valves this sculpturing is so fine that it can be seen only with difficulty by the naked eye.

Of the internal characters of this species nothing certain could be ascertained, as only very few specimens were at hand, and none could be sacrificed for the purpose of investigating the internal characters. The condition of the beak of all the specimens makes it highly probable that the internal characters are those generally prevailing in the genus *Terebratuloidea*.

The dimensions of two specimens from Katta are as follow:—

	I.	II.
Entire length of the shell	15 mm.	15 mm.
„ breadth „	16·5 „	17 „
„ thickness of both valves	11 „	10 „
Apical angle of the ventral valve	102°	104°
„ „ „ dorsal valve	118°	125°

Locality and geological position.—This species is of a very limited geological and geographical distribution. It has been detected by myself at only one locality and in a single bed. This was at Katta in a yellow, shaly, calcareous bed intercalated between compact layers of limestone, forming the very lowest beds of the compact limestone series composing the middle division of the Productus-limestone. Only three specimens were found.

Remarks.—In its general outline this species is very nearly related to *Terebratuloidea minor*, W., described before, and it would not be separable from that species were it not for the very neat concentric sculpturing which covers both valves of the present species. I think the occurrence of such a sculpturing is sufficient for the distinction of a species, as it forms a very striking character which can easily be recognised.

Of European species none can be compared to the present one.

Genus: UNCINULUS, Bayle.

I am not quite certain whether this genus is in reality distinguishable from *Rhynchonella*, as Mr. Bayle only gave the name without a description; but as the species for which the name is introduced form a very compact, easily distinguishable group, it may be practical to retain the generic designation, and thus to diminish the enormous number of forms already considered as belonging to the genus *Rhynchonella*.

The most detailed observations on the species belonging to the genus have been published by Quenstedt in his "Petrefaktenkunde Deutschlands," Vol.II, Brachiopoda. He considers all the shells more or less allied to *Rhynch. wilsoni*, as forming only one extensive species, and introduces for them all the collective name "Wilsonier," which I connot accept as of generic value. Nevertheless it apparently coincides entirely with what was indicated by Bayle under the name of *Uncinulus*. The expression "Wilsonier" was never intended by Quenstedt as a generic name, nor does it bear the form required for a generic designation. I therefore think myself justified in using the name *Uncinulus*, though it be of ater date.

The genus is not difficult to be recognised by its external form. The species belonging to it are *Rhynchonella*-shaped, covered with more or less fine radiating ribs, which generally do not begin at the apex of the valves, but only more towards the frontal part. The ventral valve bears in the middle, at the shallow sinus in the frontal region, a high rectangular lobe, which fits into a similar emargination of the dorsal valve. The ribs on this lobe are peculiar; they bear a furrow on top, and appear thus more or less bifid. This lobe is only distinctly developed in adult specimens.

In the dorsal valve the sculpturing is very similar to that of the ventral one, only that the bifurcation of the ribs is chiefly observable on the lateral lobes of this valve, whilst it is little developed on the median part.

Among the internal characters the most important seem to be the great thickening of the substance of the ventral valve, and the deep impressions it bears; it is, however, difficult to arrive at a right understanding of these impressions. Dental plates are developed as in *Rhynchonella*. In the middle, far from the apex of the ventral valve, is a kind of short median septum with two lateral branches which seems to divide the body of the animal nearly into two halves. The impressions of the adductors are where this septum terminates towards the beak.

In the dorsal valve a strong median septum is present, as in *Rhynchonella;* and also the crura are very much like those occurring in that genus. The whole hinge apparatus seems to differ from that of *Rhynchonella*, only by the hinge-plate not being divided in the middle up to the apex.

These external as well as internal peculiarities might possibly be sufficient to distinguish generically the forms bearing them from *Rhynchonella*, but I cannot positively affirm if they be so. We must await Mr. Bayle's detailed description, which perhaps will disclose some more distinctive characters, to put the genus on somewhat firmer ground.

Thus defined the genus has a rather wide geological range. It begins in the silurian period, in the upper region of which already numbers of species occur. The genus seems to be most numerously developed in devonian strata, and already in the carboniferous period species belonging to it become scarce, while in mesozoic strata nothing similar has been detected.

In the Salt-range three species belonging to the genus occur. One has been detected in the middle and upper, the other two in the upper division of the Productus-limestone, but none of them is common: all three are tolerably rare.

The occurrence of three species of this genus gives a rather old aspect to the Brachiopod-fauna of the Salt-range.

1. Uncinulus theobaldi, Waagen, n. sp., Pl. XXXIV, fig. 1.

The general outline of this species in very transversely oval, much shorter than it is broad: the valves are very strongly inflated, so much so that the thick-

ness of the shell is about equal to its length. Both valves are covered by very fine ribs which commence not very far from the apex of the valves and extend to the frontal and lateral margins. As in all the species belonging to the genus, the ribs are bifid where they approach the margins.

The ventral valve is very flat for about half of its length, where the median sinus begins, and is but little impressed. The lateral parts proceed quite straightly and are suddenly bent up close to the margin. The median part of the shell, occupied by the sinus, is prolonged in a long rectangular lobe, with vertically-ascending lateral margins. The beak is short, thin, very pointed, and well bent over. The very small foramen is situated below the apex of the beak, and seems to be limited at its lower side by deltidial plates, but this feature is not well observable in the specimens at my disposal. The very fine and numerous ribs cover barely half the extent of the valve, a large part of it in the apical region being quite smooth. Of the ribs there are seven to eight situated within the sinus, and twelve to thirteen on each lateral part, so that altogether this valve has thirty-one to thirty-four ribs, of which those most laterally situated are rather small and indistinct. The ribs situated on the sinus and its shelly prominent extension bear for a long distance from the margin a furrow on top, whilst on the ribs on the lateral parts no such furrow can be observed.

The dorsal valve is somewhat more strongly vaulted than the ventral one, but the difference is slight. In the middle region, along the median fold, the valve is nearly quite flat, whilst the lateral parts bend strongly down. This valve also bears a great many fine sharp ribs, which begin at some distance from the apex. The ribs which reach up furthest are the median ones on the median fold. Here the smooth part of the valve occupies about half its length, whilst on the lateral parts it extends further. There are altogether thirty to thirty-three ribs on this valve, nine on the median fold, and eleven to twelve on each lateral part. In this valve all the ribs are bifurcated or bear a furrow on top, but on the lateral parts this takes place for a much longer extent than on the median fold.

Of the internal characters nothing can be seen except tolerably large dental plates in the ventral valve; they are very strongly diverging, very nearly approached at the apex of the beak, and rather far distant from each other where they terminate towards the frontal region. They extend for about a fourth part of the length of the valve.

The dimensions of two specimens, one from Musakheyl and one from Chidru, are as follow :—

	I.	II.
Entire length of the shell	13 mm.	14 mm.
„ breadth „	18·5 „	20 „
Thickness of both valves	12·5 „	13·5 „
Apical angle of the larger valve	112°	114°
„ „ „ smaller valve	117°	116°

Locality and geological position.—This is a very rare species; only two specimens of it have been detected up to the present. One of them has been for a

long time in the collections of the Geological Survey. It was presented by Mr. Theobald to the Survey, and had been found by him at Musakheyl. As the shell is silicified, it is probable that this specimen came from the upper beds of the middle division of the Productus-limestone. The second specimen I collected myself at Chidru in the same bed in which *Xenodiscus carbonarius*, W., occurred in great numbers. This bed forms part of the upper division of the Productus-limestone.

Remarks.—There is one species to which the present one is very nearly related; this is *Rhynchonella (Uncinulus) timorensis*, Beyrich, from carboniferous deposits of the Isle of Timor. The two species resemble each other very much by the marked transversely oval form of their shells, and the very small and little prominent beak. They differ from each other by the greater smoothness of the shell, the by far broader median fold and sinus in comparison to the lateral parts, and by the greater flatness, or the nearly impressed form, of the ventral valve in *Rhynch. timorensis*. These points of difference are, I think, sufficient to distinguish the two shells as different species.

Of devonian species several are similar to the present one, but none, I think, needs a more close comparison.

2. Uncinulus jabiensis, Waagen, n. sp., Pl. XXXIV, fig. 2.

The general outline of this species is approximately triangular, about as long as it is broad, with not much inflated valves, which are nearly quite smooth, and only near their margins bear short, not very fine, ribs.

The ventral valve is rather flat, and but very little arched, still perhaps more strongly so than in the preceding species, forming a distinctly curved line from the apex of the beak down to the margin of the lateral parts. As in all species of the genus, that part of the valve which corresponds to the sinus is produced and forms a more or less high shelly lobe, which is, however, never so high as in the preceding species, and is limited on both sides, not by vertical, but by sloping, margins. The sinus of the valve itself is very shallow. The beak is not appressed, little bent over, prominent, thin, and very pointed. It is pierced below its extremity by a very small foramen, which is limited on its lower side by small, but distinct, deltidial plates. There is no trace of a false area along the curved hinge-line. The greater part of the valve is quite smooth, and the sinus is barely perceptible on this smooth part, which occupies three-quarters of the entire length of the valve. There are five ribs within the sinus, and about nine on each lateral part. The ribs within the sinus bear for about half of their length a furrow on top, the ribs on the lateral parts, on the contrary, being devoid of such a furrow.

The dorsal valve is almost flatter than the ventral one. The apex is strongly bent in, but from it the valve extends in nearly a straight line to near the frontal region, where it bends again down before it reaches the frontal margin. This valve also is smooth for a great extent, though not so much so as the ventral valve. The smooth part in this valve takes up only two-thirds of the entire length, where ribs

begin to appear, and reach down to the margins. There are six ribs on the slightly prominent median fold, and about ten ribs on each lateral part. The ribs on the median fold are devoid of a furrow at top, but the ribs on the lateral parts bear such a furrow for about half of their length. These ribs quickly decrease in length as they approach the hinge-margin.

Of the interior arrangements of the species nothing could be seen except the strongly-developed dental plates in the ventral valve, extending from the extremity of the beak to about one-quarter of the entire length of the valve.

The dimensions of a specimen from Jabi are as follow:—

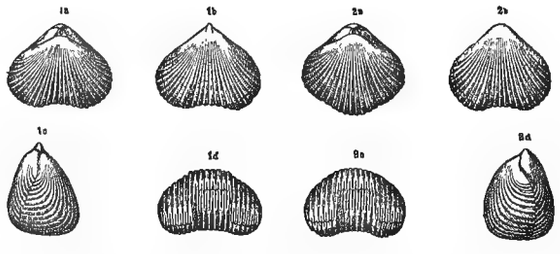
Entire length of the shell	18 mm.
Length of the smaller valve	17 „
Entire breadth of the shell	19 „
Thickness of both valves	12 „
Apical angle of the larger valve	88°
„ „ „ smaller valve	95°

Locality and geological position.—This species is everywhere exceedingly rare, except at one locality, and this is at Jabi in the upper division of the Productus-limestone, in the bed with *Cyclolobus oldhami*. I collected in this bed eight specimens, but among all these there was only one quite well preserved; the others were generally single valves. Another single valve I found at Khura in calcareous beds at the limit of the middle and upper divisions of the Productus-limestone.

Remarks.—In its great smoothness this species resembles very much *Rhynch.* (*Uncinulus*) *timorensis*, Beyrich, but otherwise the resemblance is not so very great. Beyrich's species is by far more transversely oval, and bears many more ribs than the Indian shell, and I do not think that the two could be united in one and the same species. Also with *Uncinulus theobaldi*, W., a certain relation exists; but a distinction is very easy. In *Un. theobaldi*, the smooth part in the cardinal region is much smaller, the valves much more inflated, and it is strongly oval transversely in its general outline.

Uncinulus posterus, Waagen, n. sp.

The general outline of this species is triangular, only slightly broader than it is long. The valves are tolerably inflated, covered with very fine ribs to a certain distance from the apex.



Figs. 1, 2. *Uncinulus posterus*, Waagen, n. sp. Two specimens from the Cephalopoda-bed of the upper Productus-limestone of Jabi; *a*, dorsal view; *b*, ventral view; *c*, lateral view; *d*, front view.

The ventral valve is well curved, with a slightly-developed sinus, which begins far from the apex, and is a little vaulted in the middle. This is a very strange feature, and in a certain position of the shell it causes a very peculiar aspect of the frontal view: instead of the sinus being sunk, producing an excavated line, it projects in this species as a rounded prominence. The beak is but little bent over, not appressed, thin and very pointed; it is pierced below its apex by a very small foramen. The deltidial plates cannot well be seen. On both sides of the beak there extend very small, sloping, triangular flat spaces, which form a very small false area. The smooth part, where the ribs are very fine, occupies about half the length of the valve, beginning from the apex; then the ribs become distinct. They are rounded, but very fine. There are six to seven of them within the sinus and eight to nine on each lateral part. The ribs within the sinus for a short distance near the margin bear a furrow on top; the others, however, are devoid of it. The sinus forms, as in other species of the genus, a tolerably far-projecting shelly lobe, which is rectangular and limited laterally by vertical margins.

The dorsal valve is about equally vaulted as the ventral one, but its curvature is not equally distributed. The apex is not strongly bent in, but rather flat, and the whole smooth part of the valve is flattened, and but very little vaulted in any direction. After the ribs begin to appear, the valve bends rather strongly and suddenly down; this bend is by far stronger on the lateral parts than on the median fold. The valve is entirely smooth for a short distance from the apex, then ribs are developed, but are so fine that the shell still appears nearly smooth for more than half of its length. Lower down numerous fine ribs are observable, and extend to the margin of the valve. There are seven to eight ribs on the median fold and ten to twelve on each lateral part. All these ribs bear a furrow on top in the region of the margins of the valve, but it is very short on the ribs situated in the median fold, and much larger, reaching up to nearly half of the length of the ribs, on the lateral parts of the valve.

Of the internal characters of this species the dental plates in the ventral valve can distinctly be seen; they are very strong, but not very long. The median septum in the dorsal valve is less distinctly visible. There seems to be one present, but it is not very strongly developed.

The dimensions of two specimens from Jabi are as follow:—

	I.	II.
Entire length of the shell	12·5 mm.	13 mm.
Length of the smaller valve	11 „	12 „
Entire breadth of the shell	14·5 „	14·5 „
Thickness of both valves	9·5 „	10·5 „
Apical angle of the larger valve	101°	100°
„ „ „ smaller valve	112°	108°

The species seems to remain small, and there are no larger specimens known than those of which the measurements are given.

Locality and geological position.—There are altogether not more than three specimens of this species in the Salt-range collection. All three were found by myself at Jabi in the bed with *Cyclolobus oldhami*, W., in the upper division of the Productus-limestone.

Remarks.—This species is about intermediate in its characters between *Unc. theobaldi* and *Unc. jabiensis*. Whilst in its general outline it resembles more or less the latter species, it is more allied to the first by the ribs, which are about equally fine and numerous, and begin also about half way or nearer the apex. From both those species it differs by its constantly smaller size and the greater inflation of its valves.

Of lower palæozoic species some are very similar to the shells here under consideration. Especially the forms which occur in the silurian limestones of Gothland show an extreme resemblance. But as I have no materials for comparison, I cannot exactly indicate the differences. Also the true *Unc. wilsoni*, from devonian strata, seems to be very nearly allied to the present species, but the devonian forms, though in their general outline very similar, seem to be generally more finely ribbed, inasmuch as they bear at least ten ribs on the median fold of the dorsal valve, and about twenty on each lateral part. So far the present shell can be distinguished from *Unc. wilsoni*, but it cannot be denied that the resemblance is extremely close.

It is a strange fact that here associated with *Cyclolobus oldhami* there should suddenly appear a shell which is extremely nearly allied to a common devonian form. Up to the present, allies of the species occurring in the Productus-limestone of the Salt-range had to be sought for in upper carboniferous or in permian strata, or we had even to go up as far as the trias; and now all of a sudden we come upon a group of shells which entirely points to older devonian and silurian deposits, and certain forms of which can barely specifically be distinguished from the devonian shells. I think, however, that this more isolated fact cannot materially alter the deductions which we may draw from the overwhelming evidence of the other species as to the geological age of the palæozoic deposits of the Salt-range. That species of *Uncinulus* go up also into the carboniferous formation we know already from the occurrence of *Unc. cuboides* in the carboniferous limestone of Belgium, and of *Unc. timorensis* in the carboniferous deposits of the Isle of Timor. Thus it may well happen that species should also be found in the Productus-limestone of the Salt-range.

Genus: RHYNCHONELLA, Fischer v. Waldheim.

This genus is very well known, and needs no explicit description. From the typical species *Rhynch. loxia*, which has been figured again in Zittel's Hand-book of Palæontology, it appears that it possessed strong dental plates in the ventral valve and an equally strong septum in the dorsal one, and thus those shells which agree in

these points with the typical species must be considered as forming the genus. Thus also those forms which have been distinguished by Hall under the name of *Stenoschisma* fall within the scope of this genus, and Hall's genus can scarcely be retained any longer.

Thus defined, the genus commences already in silurian strata, is numerously represented during devonian and carboniferous times, but seems to attain its chief development in the mesozoic epoch, where it is most largely developed in the jurassic period. During cretaceous times with true *Rhynchonellæ* other genera appear and seem partly to replace that genus; but the cretaceous generic forms seem not to be yet thoroughly studied. In the actual seas the true *Rhynchonellæ* are replaced entirely by the genus *Hemithyris*.

In the Salt-range there are three forms which I can assign safely to the typical genus. All three are extremely rare. One of them belongs to the group of *Rhynch. pleurodon*, Phill., but can easily be distinguished by its very inflated valves and nearly globose form. Another species has a great propensity to become unsymmetrical, and in this respect is not dissimilar to *Rhynch. latoma*, Barr., from upper silurian strata, or to *Rhynch. mantiæ*, Sow., from the carboniferous. The third species has only been detected in a single valve, and cannot be determined specifically, yet there is no doubt that by this single specimen the existence of a third species is indicated.

The great rarity of species of *Rhynchonella* in the strata of the Salt-range is not without geological importance. Zittel, in his Hand-book, says that in the permian formation (Zechstein) the genus *Rhynchonella* is replaced by *Camerophoria*. Though this is not exactly true for the whole surface of the globe, yet a remarkable fact is hinted at by Zittel's words, that really during permian times *Rhynchonellæ* became very scarce, so that we can speak of a minimum of development during these times whilst the *Camerophoriæ* become exceedingly numerous. Only in America have several species of *Rhynchonella* been observed in permian strata; but otherwise, *Rhynchonella geinitziana*, which is in reality a *Rhynchopora*, is generally quoted as the only representative of the genus in Europe and Asia during permian times.

Camerophoriæ, on the contrary, are very common in the permian formation, though not so numerous in species as in individuals.

Exactly the same is the case in the palæozoic deposits of the Salt-range. Of true *Rhynchonellæ* only three species are present, which are so exceedingly rare that only one or two specimens of each have been detected up to the present. Even if we include the species of *Uncinulus*, the aspect of facts is not materially altered, as these also are very rare. We have then six species of *Rhynchonella* and *Uncinulus* together to compare with five species of *Camerophoria*, of which four are very common. Thus an observer travelling along the escarpments of the Salt-range will meet with numbers of *Camerophoriæ* before he will find one specimen of a *Rhynchonella*, if he detects even one.

This comparative prevalence of *Camerophoria* is a fact very worthy of notice.

1. Rhynchonella wynnei, Waagen, n. sp., Pl. XXXIV, fig. 4.

This species is nearly globular in its general outline, very little broader than it is long, with extremely inflated valves, which are covered with strong, not very broad, sharp radiating ribs. Six of these are on the moderately prominent median fold.

The ventral valve is very strongly and very equally curved, forming nearly a semicircle from the apex of the beak down to the end of the median sinus. The sinus is only very little impressed, but very broad, occupying the greater part of the breadth of the whole shell. The lateral parts are correspondingly very narrow and little prominent, as is most distinctly seen in a front view of the shell. The beak is very short and pointed, not bent over, and pierced below its apex by a small foramen, which seems not to be limited at its lower side by deltidial plates. From both sides of the beak rather broad, flat, smooth, triangular spaces extend; they are, however, strongly sloping, and form only a very indistinct false area. The ribs begin at a short distance from the apex, and are strongest on the frontal margin. There are five ribs within the sinus, and about six much smaller ones on each lateral part. The frontal line is not quite distinctly visible on account of the bad preservation of the only specimen.

The dorsal valve is about equally strongly vaulted as the ventral one, but its curve is much more irregular. From the apex to near the frontal part of the shell it is not very much curved, then it bends down rather suddenly to meet the ventral valve. The ribs begin at some distance from the apex. The median fold is but little prominent, and bears six ribs, which are rather high and tolerably sharp near the frontal margin. On the rather narrow lateral parts there are about seven ribs, which are, however, much shorter and less strong than the ribs in the median fold.

Of the internal arrangements of this species nothing can be observed, but a trace of the rather strongly developed dental plates in the ventral valve.

The measurements of the only existing specimen are as follow:—

Entire length of the shell	14 mm.
Length of the smaller valve	13 „
Entire breadth of the shell	16 „
Thickness of both valves	13 „
Apical angle of the larger valve	102°
„ „ „ smaller valve	110°

Locality and geological position.—Up to the present only one specimen of this species has been detected. It was found by Mr. Wynne on the hill above Kálabágh in calcareous beds apparently at the limit between the middle and upper divisions of the Productus-limestone.

Remarks.—As there is but one specimen, it is rather difficult to indicate the differences of this species from other allied forms. There is chiefly *Rynch. pleurodon*,

Phill., to be compared. If we consider only an upper view of the dorsal valve, it cannot be denied that in this aspect the two species are very similar; but in any other view the similarity immediately ceases. In the ventral valve the lateral parts are much more strongly developed, slightly impressed, and angularly prominent in *Rynch. pleurodon*. In a front view the median fold is more prominent, the sinus more deeply impressed, and the whole outline not so rounded in Phillips' species. All these differences have their origin in the much greater inflation and different curvature of the valves of the Indian shell. They are, however, sufficient to distinguish the two forms as separate species.

Another species, which is in general outline not dissimilar to *Rhynch. wynnei*, is *Rhynchopora geinitziana*, Vern. sp. Even if we do not take into consideration that the permian species belongs to a different genus, there are in the external forms sufficient differences to distinguish the two species. *Rhynch. wynnei* has more inflated valves and coarser and less sharp ribs than *Rhynch. geinitziana*. But also the genus is different. In the Indian shell the punctation characteristic of the genus *Rhynchopora* is decidedly absent, whilst *Rhynchopora geinitziana* decidedly bears such a punctation, as this character has served for the definition of the genus.

2. Rhynchonella morahensis, Waagen, n. sp., Pl. XXXIV, fig. 5.

This is a small species of elongated oval form, slightly inflated valves, with small sinus in the ventral and corresponding fold in the dorsal valve, and not very numerous, sharp, radiating ribs, which begin at the apex of the valves.

The ventral valve is rather flat for its whole extent, and shows a very equal curve throughout. The sinus is narrow and not deep, the lateral parts comparatively broad. The beak is not well preserved in any of my specimens, but it seems to have been very prominent and tolerably long. On both sides of the beak extend very sloping, smooth, triangular spaces, which form only a very indistinct false area. The ribs do not begin immediately at the beak, but at a little distance from it. They are sharp and comparatively high. There are only two of them within the sinus and seven on each lateral part. The sinus is not quite central, but shifted a very little to the right side. This peculiarity is not represented in the drawing, Pl. XXXIV, fig. 5*e*.

The dorsal valve shows the same curvature as the ventral one. The median fold is very little prominent and shifted a little to the right side. The ribs begin only at a little distance from the apex and soon become sharp and high. There are three ribs on the median fold and six on each lateral part.

Of the internal structure of this species nothing can be seen, the interior of the specimen is so strongly sparry that it is impossible to decide with certainty whether dental plates are present in the ventral valve or not. It has however the appearance as if there were.

The measurements of a specimen from Morah are as follow:—

Entire length of the shell, about	11 mm.
Length of the smaller valve	9·5 „
Entire breadth of the shell	8·5 „
Thickness of both valves	6 „
Apical angle of the larger valve	85°
„ „ of the smaller valve	91°

Another specimen, of which I am, however, doubtful whether I should consider it as belonging to the same species, measures 13 mm. in length and 11 mm. in breadth. It bears four sharp ribs on the very little prominent but strongly shifted median fold, and there are only four folds on each lateral part of the dorsal valve.

Locality and geological position.—The specimen which served for the description of this species was collected by Mr. Wynne at Morah in the middle division of the Productus-limestone. The second specimen, which doubtfully belongs to the species, also comes from the middle division of the Productus-limestone, at Musakheyl, where it was found by Mr. Theobald.

Remarks.—This species is remarkable for the unsymmetrical development exhibited by both the specimens. Unsymmetrical species of *Rhynchonella* have been already found in the Silurian, as represented by *Rhynch. latoma*, Barr. I do not think that in all cases the unsymmetry is caused by a malformation; very often it seems to be a specific character exhibited in a more or less strong degree by all specimens belonging to the species. Also in carboniferous strata such unsymmetrical forms are known to occur, and they received from Sowerby the name of *Terebratula mantiæ*. Davidson considers this form only as a malformation of *Rhynch. pleurodon*, Phill., but if we consider the beautiful drawing in the "British Carboniferous Brachiopoda," the general outline of the figure is very different from that of Phillips' pecies; the length in *Rhynch. mantiæ* is slightly greater than the breadth, whilst in *Rhynch. pleurodon* the breadth exceeds very considerably the length of the shell. I therefore should be rather inclined to consider *Rhynch. mantiæ* as a different species. To this species the Indian *Rhynch. morahensis* is rather nearly related. The general outline is very like that of *Rhynch. mantiæ;* in both species the length exceeds the breadh of the shell, the median fold is in both shifted more or less to the right side, and the ribs are similarly distributed. The two forms can be distinguished by the less prominent median fold, and more shallow corresponding sinus and the less numerous ribs in *Rhynch. morahensis*.

3. Rhynchonella *sp., indet.*, Pl. XXXIV, fig. 3.

It is to be regretted that this species has been found by me only in a single valve, and this even is not quite complete. Among all the shells occurring in the Salt-range it is the one most nearly related to *Rhynch. pleurodon*, Phill.

The single specimen consists of a dorsal valve, slightly broken in the frontal region. The valve is very flat and resembles in this respect more or less fig. 10 (*non* 10 *a*), Pl. XXIII of the "British Carboniferous Brachiopoda." Its curvature is very equal throughout, but in the apical region it bears a slight longitudinal impression very much like that in the dorsal valve of all the specimens of *Rhynch. pleurodon* available for comparison. There is barely a trace of a median fold. The whole valve is covered by strong radial folds, which begin only at a certain distance from the apex. There are altogether twelve folds on this valve. In the interior there seems to be a strong median septum.

The measurments of this specimen are as follow :—

Entire length of the dorsal valve	10 mm.
„ breadth „ „ „	10 „
Thickness „ „ „	3 „
Apical angle „ „ „	102° „

Locality and geological position.—The only specimen of this species that has been detected up to the present was found by myself at Amb in the lower division of the Productus-limestone, in a black coaly sandstone, the so-called *Chonetes*-bed.

Remarks.—Though this species resembles to a certain degree young specimens of *Rhynchonella pleurodon*, yet I should not like to directly unite it with that species on account of the general outline of the specimen, in which the length and the breadth of the shell are identical. For a final judgment in the matter better materials must be found.

Sub-family: *CAMEROPHORIINÆ*, Waagen.

Genus: CAMEROPHORIA, King.

This is one of the best characterised and most easily recognisable of known genera. It is barely necessary to say anything about its internal structure, as this is very well known, and I am not in a position to adduce any new facts that would serve for the further elucidation of the genus.

Though, however, the characters of the genus are so very well known, and the group of forms comprised by it has been excellently characterised already by the first describer, yet it is very difficult to indicate exactly the geological time at which the genus first made its appearance. It is probable that the genus took its origin from *Pentamerus* by a certain reduction of the internal septa; but it is also possible that forms like *Stricklandia* or *Camerella* may have been the ancestors of *Camerophoria*. One of the most striking external characters of *Pentamerus* is the position of the sinus on the dorsal valve and a corresponding fold on the ventral one. This position of sinus and fold prompted M. Quenstedt to create the name *Antirhynchonella*. Already in silurian strata, however, isolated species

occur, in which the opposite configuration obtains. Such species are, for instance, *Pentamerus linguiferus*, Barr., and *Pent. ambigena*, Barr. In such cases the distinctive characters between *Pentamerus* and *Camerophoria* rest chiefly on the internal structure. The very strong and broad median septum in the ventral valve in these cases indicates such forms as *Pentameri*. Whether among silurian species of *Pentamerus* bearing an up-curved frontal line, there may not be one or other which possibly could be considered as a *Camerophoria* is very uncertain. It is, however, certain that in the devonian period already a number of species belonging to the latter genus have been detected. In carboniferous strata the genus is strongly developed, and counts there about eight to ten species. The genus is not so rich in species in the permian period, not more than five or six species having been described. Some of them are, however, extremely rich in individuals, as for instance *Cameroph. schlotheimi*, Buch, which is found at certain localities in hundreds. After the permian period the genus suddenly disappears; there is no species known from triassic strata.

In the Salt-range not less than five species occur. Three of these belong to the group of *Camerophoria crumena*, Mart. These are *Cam. purdoni*, Dav., *Cam. pinguis*, Waagen, n. sp., and *Cam. humbletonensis*, Howse. Of these three species only the first is common, the other two being rather rare. The geological distribution of the three species is not very different. All three occur in the middle division of the Productus-limestone; but whilst *Cam. pinguis* and *Cam. humbletonensis* are restricted to the middle region of that division, *Cam. purdoni* extends up to the very limit of the upper division. The remaining two species belong to the group of *Cameroph. rhomboidea*, Phill.: they are *Cameroph. globulina*, Phill., and *Cameroph. superstes*, Vern., both being found in the upper division of the Productus-limestone. Of these five species, three—*Cam. humbletonensis*, *Cam. globulina*, and *Cam. superstes*—are found elsewhere in permian strata, and their occurrence in the Salt-range is of great geological importance.

There is still something to be said as to why I use the name *Camerophoria* for these shells, and not as Dall wants to have it, the name *Stenoschisma*, Conrad. Mr. Dall advocates this course on the ground that Conrad proposed the name *Stenoschisma* for *Terebratula schlotheimi*, Buch—that is, for the same species for which King proposed the name *Camerophoria*. This, however, is only verbally the case. It is most evident that Conrad mistook some other species for *Terebratula schlotheimi*, as Buch's species has, as far as I am aware, not yet with certainty been stated to occur in America, and is a species exclusively restricted to permian strata. Mr. Conrad created his name *Stenoschisma* for the common silurian bivalve which he indentfied with *Terebratula schlotheimi*, Buch, but which is certainly not identical with Buch's species. Thus there is not the slightest doubt that the name *Camerophoria* denotes something quite different from that for which the name *Stenoschisma* was created, and it is most certain that there is not any possibility of the two genera being identical. I cannot say whether Mr. Hall is

right in his interpretation of *Stenoschisma*, but I am quite sure that *Camerophoria* is no synonym of *Stenoschisma*.

I.—Group of *CAMEROPHORIA CRUMENA*, Mart.

1. Camerophoria purdoni, Davidson, Pl. XXXII, figs. 1—7.

1862. *Camerophoria purdoni*, Davidson: Quart. Journ. Geolog. Soc., Lond., Vol. XVIII, p. 30, pl. II, f. 4.
1863. *Camerophoria purdoni* (Dav.), Koninck: Fossiles paléoz. de l'Inde, p. 36, pl. XII, f. 4.

This species attains considerable dimensions. Its general outline is transversely oval or slightly triangular, chiefly in young specimens. The valves are not much inflated, the ventral one bears a rather shallow sinus, and the dorsal a correspondingly moderate median fold. The ribs on both valves are tolerably numerous. The species shows a great tendency to become unsymmetrical.

The ventral valve is rather flat, with a very shallow median sinus, which is generally rather broad in comparison with the much narrower lateral parts. The beak is very small and pointed, strongly bent over, and bears at its lower side a triangular slit, which begins first at the apex of the beak and extends down to the hinge-line. No trace of deltidial plates can be observed. The smooth triangular spaces on both sides of the beak are large and strongly sloping, forming a rather large but indistinct false area. The whole valve is covered by more or less strong radial ribs the number of which is very irregular. There are generally seventeen ribs on this valve, which are sometimes, but not very often, augmented to eighteen or nineteen, but sometimes, and this more often occurs, they are reduced to so few as ten or eleven. These ribs are mostly rather high and prominent, but never quite acute on top. They are mostly undivided from beginning to end, but sometimes near the frontal margin, thinner ribs are intercalated between the original ones, and then the ribbing appears very irregular in strength. There are generally five ribs within the sinus, sometimes six, or very rarely even seven, whilst more often the number is reduced to four or occasionally to three. The lateral parts of the valve only exceptionally have the same number of ribs; there is mostly one rib, sometimes even two, more on one side than on the other; generally five ribs on the one side and six or seven on the other. From this arrangement it happens that the sinus in this valve appears only rarely to be quite median, being nearly always shifted more or less to one or the other side, but there is no rule as to which.

The dorsal valve is somewhat more strongly vaulted than the ventral one, but its median fold is very little prominent and rather flattened on the top. What has been said about the ribs in the ventral valve applies also to this valve, only that the number of ribs is generally slightly larger in this valve than in the other. There are generally six ribs on the median fold, very rarely eight, and somewhat more often five or four. The lateral parts bear generally five ribs, but very often there are on one side five, whilst the other has six or seven.

Both valves, when well preserved, bear expansions on their frontal and lateral margins; but the extent of these cannot be indicated, as no entirely complete

specimen has been observed up to the present. Figs. 1 and 2, Plate XXXII, show traces of these expansions.

The internal arrangements, except the crura and the cardinal process, can be tolerably well observed. In the ventral valve the dental septa form two vaulted plates, making an ogival chamber between them under the beak; they meet not far from the bottom of the valve, where they are fixed to a very low median septum or thickening that extends however only two-thirds of the length of the plates, which for the last third of their extent towards the frontal margin are free, entirely separated from the bottom of the valve. The length of the ogival chamber reaches nearly half the length of the valve.

In the dorsal valve there is an extremely high median septum, supporting the spatula-shaped plate. The latter is strongly concave on its upper side, smooth and showing no raised line in the middle, as is the case in the European species of Camerophoria; but, on the contrary, the middle line is excavated. At the frontal extremity this plate terminates in three broadly-rounded lobes, of which the middle one is most prominent.

The dental plates of the ventral valve and the spatula-shaped plate of the dorsal one approach each other very closely for their whole extent, and it is difficult to conceive in what manner the crura can have been arranged in this species, as in reality the spatula-shaped plate fits within the ogival chamber formed by the dental plates. Certainly the crura must have been very short.

The dimensions of three specimens from Musakheyl, No. I with eight ribs on the median fold, No. II with five, and No. III with six, all three apparently full grown, are as follow:—

	I.	II.	III.
Entire length of the shell	24 mm.	22 mm.	21 mm.
Length of the smaller valve	22 „	21 „	20 „
Entire breadth of the shell	28 „	29 „	27 „
Breadth of the median fold	15 „	15 „	14 „
Thickness of both valves	15 „	15·5 „	15 „
Apical angle of the larger valve	98°	105°	97°
„ „ „ smaller valve	107°	111°	103°

Locality and geological position.—This species is very common in the Salt-range, but seems to be restricted to the middle division of the Productus-limestone.

The greatest number of specimens, but mostly not well preserved, was collected by Mr. Wynne at Morah in a marly crinoidal limestone which apparently belongs to the middle region of the middle division of the Productus-limestone. There are not less than nineteen specimens from that locality. Next comes Musakheyl, as regards the number of specimens, altogether fourteen, collected partly by Mr. Theobald, Dr. Oldham, Dr. Warth, and myself. At other localities the species is not rare, but has not been collected in so great numbers as at the places just mentioned. It has been found in the section at Khura in the top beds of the calcareous series, forming there the middle division of the Productus-limestone (four specimens); at Chidru in the highest beds of the compact limestones (one specimen); at Virgal in the coral limestone

(one specimen); and Trans-Indus at Káfirkot (one specimen). By Mr. Wynne it has been collected at Swás (three specimens), Chidru (one specimen), and Trans-Indus at Kálabágh (one specimen).

The species very rarely extends up into higher strata. I have collected two specimens west of Khura at the base of the upper division of the Productus-limestone, and a single very bad specimen, which barely admits of an exact determination, in the section near Khura in the middle region of the upper division.

Remarks.—This species is very nearly related to *Cameroph. humbletonensis*, Howse, and it is often not easy to distinguish the two. The specimen figured by Davidson is a somewhat exceptional variety, remarkable on account of the somewhat smaller apical angle of its ventral valve. The ribs are broad and strong, as is generally the case in specimens which bear only five ribs on the median fold of the dorsal valve; this fold itself is very low and the corresponding sinus very shallow, as in the specimens represented on Pl. XXXII. I thus think myself entirely justified when I consider all these specimens as belonging to Davidson's species. The most characteristic feature of this species, then, is the great shallowness of the sinus in the ventral and the very little prominence of the median fold in the dorsal valve. The absence of lateral and frontal expansions, which are indicated by Davidson as a specific character, does not hold good, as when well-preserved specimens are accessible they always show traces of such expansions.

On the whole, the differences from *Cam. humbletonensis* are very small, and chiefly consist in the shallowness of the median sinus and fold, and in the ribs being generally less numerous than in Howse's species. Nevertheless I was a long time in doubt whether I should not consider the two species as identical, until I was able to expose the internal characters to a certain extent. In these characters very marked differences exist between the two species. If one compares the lateral view of the interior processes, as drawn by King, with fig. 6 on Pl. XXXII, these differences are very striking. The outline and development of the dental plates is quite different in the two species. The spatula-shaped process is far distant from the lower margin of the dental plates in *Cam. humbletonensis*, whilst the two organs are quite approached in the Indian shell, also the form of the spatula-shaped process is different. Similar differences exist also between the internal characters of *Cam. schlotheimi* and those of the present species, but they are less considerable.

There is also some similarity between *Cam. purdoni* and certain varieties of *Cam. crumena*, Mart.; chiefly those specimens figured by Beyrich from the Island of Timor approach very near to the Indian shells in general form, but the *Cam. purdoni* is distinct in every case from the true *Cam. crumena* by its very shallow sinus and little prominent median fold.

On the whole, the present species seems to be more nearly related to permian than to carboniferous species.

2. Camerophoria humbletonensis, Howse, Pl. XXXII, figs. 8, 9.

1848. *Terebratula humbletonensis*, Howse: Cat. Foss. Perm. Syst.; T. N. F. C., Vol. I, pt. III, p. 252.
1846. *Camerophoria multiplicata*, King: Ann. Mag. Nat. Hist., Ser. I, Vol. XVIII, p. 28 (nom.)
1850. *Camerophoria multiplicata*, King: Mon. Perm. Foss., p. 121, pl. VII, figs. 26—32; pl. VIII, figs. 1—7.
1858. *Camerophoria humbletonensis* (Howse), Davidson: Mon. Brit. Perm. Brach., p. 27, pl. II, figs. 9—15.

The general outline of this species is transversely oval or slightly triangular. The dorsal valve bears a tolerably narrow, prominent, rounded median fold, and the ventral one a deep corresponding sinus. Both valves are covered by very numerous fine radiating ribs.

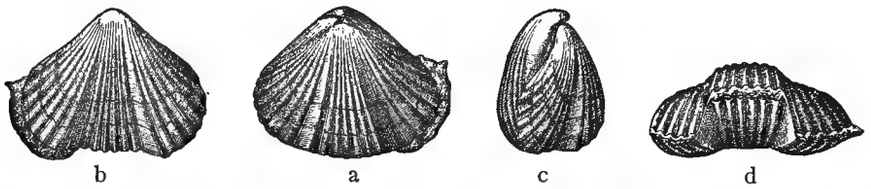


Fig. 3. *Camerophoria humbletonensis*, Howse, sp. Specimen from the coral-beds of the middle Productus-limestone of Virgal: a, dorsal view; b, ventral view; c, lateral view; d, front view.

The ventral valve is rather strongly curved in the region of the sinus; the lateral parts, however, are very much bent down and nearly straight. The beak is very small, pointed, and much bent over, so much so that the triangular opening is barely at all visible. The smooth spaces which extend on both sides of the beak are narrow and very elongated, strongly sloping. The ribs begin at a short distance from the apex of the beak, and are slightly more numerous in the apical region than near the margins of the valve, as some of them on both sides of the sinus disappear before they reach the margin. There are twenty to twenty-five ribs on this valve, of which six to eight are within the sinus, and seven to eight on each lateral part. The ribs are not sharp but rounded on top.

The dorsal valve is somewhat more strongly vaulted than the ventral one, but the curvature is not equal, as the middle part, corresponding to the median fold, is less strongly curved than the lateral parts. The median fold is vaulted and prominent, but not very broad. The ribs begin at a little distance from the apex of the valve. There are twenty to twenty-six ribs on this valve, of which seven to eight are on the median fold, and six to nine on each lateral part.

All along the lateral and frontal margins of both valves rather narrow expansions extend exactly like those drawn by Davidson on his Pl. II, fig. 9.

Of the internal characters of the species nothing could be ascertained in the Indian specimens, except the existence of the curved and oblique dental plates characteristic of the genus.

The dimensions of three specimens, all from Virgal, are as follow:—

	I.	II.	III.
Entire length of the shell	21 mm.	20 mm.	16·5 mm.
Length of the smaller valve	20 „	19 „	15 „
Entire breadth of the shell	25·5 „	26 „	16 „
Thickness of both valves	15·5 „	14·5 „	9·5 „
Apical angle of the larger valve	94°	97°	79°
„ „ „ smaller valve	105°	114°	93°

Locality and geological position.—There have only been four specimens of this species detected up to the present in the Salt-range. Three of them were found by myself at Virgal in a compact limestone intercalated between coral beds in the middle region of the middle division of the Productus-limestone; another specimen was collected by Mr. Wynne Trans-Indus at Bilot, in the crinoidal cliffs belonging also to the middle division of the Productus-limestone.

Remarks.—There can, I think, not be much doubt as to the identity of the Indian specimens with the European species. The former are distinct from *Cam. purdoni*, Dav., by their somewhat narrower and more elevated fold, and the more excavated sinus, and by the much finer and more numerous ribs, characters which are quite identical with those of *Cam. humbletonensis*. I have taken very much trouble to detect characters in these Indian specimens which would allow of a distinction between them and the European forms, but I was absolutely unable to detect any. I had for comparison some specimens from Humbleton which are preserved in the Hof-Mineralien Cabinet at Vienna; but though these specimens are internal casts and the Indian ones are testiferous, yet the similarity is so very great that I cannot doubt of their all belonging to one and the same species. Even the young specimens, of which the measurements are given above under No. III, so closely resemble the fig. 31 on Plate VII of King's monograph, that there remains no doubt as to the identity of the species.

The occurrence of this well-known permian species in the strata of the Salt-range is of great geological importance.

3. Camerophoria pinguis, Waagen, n. sp., Pl. XXXII, figs. 10, 11.

The general outline of this species is transversely oval, considerably broader than it is long. The median fold is rather prominent and rounded, the sinus is rather deep. Both valves are covered by thick rounded ribs, which are little numerous.

The ventral valve is strongly inflated and curved, the curve being throughout tolerably equal. The ribs commence rather far from the apex of the beak. There are altogether twelve to fourteen ribs on this valve, three or four within the sinus and four to five on each lateral part. The beak is rather thick, strongly bent over, so as barely to show the triangular aperture below it. The flat triangular spaces on both sides of it are broad and sloping, forming a broad false area.

The dorsal valve is also strongly vaulted with a rather equal curve. It is rather inflated in the apical region, and there extend on both sides of the apex broad

smooth spaces, which form also in this valve a kind of false area. The ribs commence at some distance from the apex. There are altogether eleven to thirteen ribs on this valve, of which three to five are on the median fold. If there are four or five ribs present, the two or three median ones are stronger than the two lateral. On each lateral part there are three or four ribs.

There is no specimen in which it could be seen whether the valves bore lateral and frontal expansions; nevertheless I think it probable that when complete specimens will be found such expansions will be detected.

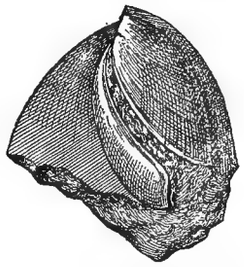


Fig. 4. Camerophoria pinguis, Waagen, n. sp. Specimen showing the internal characters, from the coral beds of the middle Productus-limestone of Virgal: lateral view, enlarged.

The internal arrangements of this species are very much like those occurring in *Cam. purdoni*, Dav., but the dental plates as well as the median septum in the dorsal valve are shorter than in that species. The spatula-shaped process has the same form in both species, but does not fit within the ogival chamber formed by the dental plates, but extends in front over this chamber. The crura have not been observed.

The measurements of two specimens, No. I, from Morah, and No. II, from Virgal, are as follow:—

	I.	II.
Entire length of the shell	23 mm.	20·5 mm.
Length of the dorsal valve	21 „	19 „
Entire breadth of the shell	27 „	23·5 „
Thickness of both valves	16 „	16 „
Apical angle of the large valve	91°	94°
„ „ „ smaller valve	98°	96°

Locality and geological position.—This species is rather rare in the Salt-range, and has been detected up to the present only at three localities, but everywhere in the middle region of the middle division of the Productus-limestone. In this position the species has been found by myself at Virgal in the coral beds (two specimens), by Mr. Wynne it was collected at Morah (also two specimens), and the last specimen was found by Mr. Theohald, but the exact locality it came from is not known. From its mode of preservation it is probable that it was collected at Swás.

Remarks.—This species can be distinguished from others by its strongly-inflated and well-curved valves, its strongly-prominent median fold, and the thick, rounded, and little numerous ribs covering both valves. Also the broad false area in both valves is a remarkable character. By these peculiarities it can well be recognised in all cases, and thus it may also be considered as a well-distinguishable species. Otherwise the species seems to be more or less nearly related to *Cam. purdoni* and

Cam. crumena, Mart., but not so much to *Cam. schlotheimi*, Buch. From the first of these species it can be sufficiently distinguished by the characters indicated above, but to the second it seems to be much more closely allied. Also here, however, characters can be indicated which make a distinction not so very difficult. Chiefly the Indian species has a much more strongly inflated ventral valve. The ribs also have a different character; they are thick and broadly rounded on the top, and begin nearer to the apex of the valves than is the case in most specimens of *Cam. crumena*. If the interior of *Cam. crumena* is identical with that of *Cam. schlotheimi*, as is affirmed by Mr. Davidson, then the Indian species presents very marked differences in this respect. As in *Cam. purdoni*, so in this species the spatula-shaped process approaches very closely the margins of the ogival chamber, so that there remains no room for large crura between the two. In *Cam. schlotheimi* these two parts are rather distant from each other. But also the septum in the dorsal valve is far shorter and less high. Thus I think *Cam. pinguis* can safely be distinguished from *Cam. crumena* as a separate species.

Of other species, *Cam. plicata*, Kutorga, must still be compared. Young specimens of this species are rather similar to *Cam. pinguis*, chiefly on account of the great inflation of their valves, and the coarse folds by which they are covered. But not to speak of the much more considerable dimensions Kutorga's species attains, the internal arrangements of this species, which have been figured by Möller, are entirely different.

Group of *CAMEROPHORIA RHOMBOIDEA*, Phill.

4. Camerophoria globulina, Phill., Pl. XXXIII, figs. 13, 14.

1834. *Terebratula globulina*, Phillips: Enc. Met. Geol., Vol. IV, Pl. III, fig. 3.
1850. *Camerophoria globulina* (Phill.), King: Monogr. Perm. Foss., p. 120, Pl. VII, figs. 22 to 25.
1858. *Camerophoria globulina* (Phill.), Davidson: Monogr. Brit. Perm. Brach., p. 27, Pl. II, figs. 28 to 31.

The general form of this species is globular, the length and breadth of the shell being about equal and the thickness not much less. The surface of the shell is nearly quite smooth, and only on the margins are slight folds indicated. Sinus and fold are not much developed. The shell never attains considerable dimensions.

The ventral valve is very strongly vaulted, approximately hemispherical, nearly for its entire length without a sinus, produced in the frontal region into a not very broad lobe, causing the frontal line to ascend. This lobe is slightly impressed, forming a kind of shallow sinus. The whole valve is smooth, except near the margins, where within the sinus one fold, and on each lateral part two, are developed. The beak is very small, pointed, and strongly bent over, but not appressed, its very small foramen being distinctly visible below the apex. There is a very small and indistinct false area.

The dorsal valve is about as strongly vaulted as the ventral one, perhaps slightly more so. It is also smooth for nearly its whole extent, and only near the margins

short folds make their appearance. The median fold is very little prominent and entirely restricted to the frontal region. It bears two distinct short ribs, and on each lateral part two other ribs, but less distinct, are visible.

There are no traces of marginal expansions observable on any of the Indian specimens. Also of the internal characters of this species nothing could be ascertained beyond what can be observed through the transparent shell. In the ventral valve there is a strong median septum, which is bifid towards the apex of the beak, and occupies one-third of the entire length of the shell. In the dorsal valve the septum is less strong, undivided, and occupying not quite one-third of the length of the valve.

The measurements of the only two specimens, No. I from Jabi and No. II from Chidru, are as follow:—

	I.	II.
Entire length of the shell	7·5 mm.	8 mm.
Length of the dorsal valve	6 „	7 „
Entire breadth of the shell	7·5 „	7 „
Thickness of both valves	6 „	5 „
Apical angle of the ventral valve	87°	84°
„ „ „ dorsal valve	101°	102°

Locality and geological position.—The only two specimens of this species which have been found up to the present were collected by myself, one at Jabi in the Cephalapoda bed there, the other at Chidru in the corresponding bed, and thus both form part of the fauna of the upper division of the Productus-limestone.

Remarks.—I think there can be but little doubt that the little shells here under consideration are really identical with Phillips' *Cameraphoria globulina:* not only in the more extended sense that Davidson has given to Phillips' species, but also in a most restricted sense, they can be identified with that form. I cannot enter here upon a controversy, whether *Cam. globulina* and *Cam. rhomboidea*, Phill., form two distinct species or not; I can only say that all the specimens of the two forms I had occasion to compare were distinguishable by the respective shapes of their ventral valves. In *Cam. rhomboidea* the ventral valve is much flatter, much less strongly vaulted, than in *Cam. globulina*. This feature is most strikingly expressed in a frontal view, and it comes out beautifully in Davidson's excellent drawings, chiefly in those on Plate 54 of the Carboniferous monograph, where the two species are placed side by side for comparison.

In this peculiarity the Indian shell agrees exactly with the true *Cam. globulina* from the permian strata, and not with the carboniferous *Cam. rhomboidea*—a fact again of high geological importance.

Of other species, perhaps *Cam. verneuili*, Gruner., might be compared, but this is already easily distinguishable by its larger size and much flatter valves.

5. Camerophoria superstes, Verneuil, Pl. XXXII, figs. 12, 13.

1845. *Terebratula superstes*, Verneuil: in Murchison, Verneuil and Keyserling; Geology of Russia, Vol. II, p. 104, Pl. VIII, fig. 5.

The general outline of this species is roundish triangular, generally somewhat longer than it is broad. The valves are very inflated, smooth for the greater extent, and only near their margins provided with rather indistinct ribs. The sinus and median fold are not very strongly developed, and are limited to the frontal region.

The ventral valve is well rounded in every direction with a fairly equal curve, though it is somewhat more strongly vaulted in the apical than in the frontal region. The beak is rather thick, very strongly pointed, entirely bent over and firmly appressed, pierced just at its extremity by an extremely fine foramen. The flat spaces on each side of the beak are narrow but very long, marked off from the remainder of the shell by an obtuse ridge, thus forming a tolerably distinct false area. The valve is smooth for about two-thirds of its length, then not very distinct ribs begin to appear, of which two are within the sinus and three on each lateral part. The ribs, chiefly on the lateral parts, are often barely discernible. The sinus, as has been said above, is shallow, and extends not quite half way up from the frontal margin.

The dorsal valve is slightly more strongly vaulted than the ventral one. It also is smooth for the most part. The median fold begins to appear half way between the apex and the frontal margin; the ribs appear even later. They are always rather indistinct and ought to be somewhat less strongly marked on the figures on Plate XXXII. There are three ribs on the median fold, and three to four (it is difficult to count them) on each lateral part.

In none of the specimens at my disposal can even the slightest trace of marginal expansions be seen; and it is probable that marginal expansions really never existed in this species.

The internal arrangement of this species has been excellently described by de Verneuil, but I am not able to add anything to this description, as in none of the Indian specimens is this structure visible. The shell, however, is quite transparent in the Indian fossils, and the presence of a septum in the ventral as well as in the dorsal valve can be distinctly seen. This septum occupies in the ventral valve a little more than one-third of the entire length of the shell. In the dorsal valve it is somewhat shorter and takes up just one-third of the length of that valve.

The measurements of two specimens from Jabi are as follow:—

	I.	II.
Entire length of the shell	16 mm.	12·5 mm.
Length of the smaller valve	14·5 „	11 „
Entire breadth of the shell	13·5 „	11·5 „
Thickness of both valves	11 „	10 „
Apical angle of the larger valve	99°	95°
„ „ „ smaller valve	105°	103°

There is no specimen among the Indian materials so large as M. de Verneuil's original, which measures 17 mm. in length and 16 mm. in breadth, the general size being that indicated by No. I.

Locality and geological position.—The species is not rare in the upper division of the Productus-limestone at certain localities, and has been found by me in the Cephalopoda bed at Jabi (seven specimens), and in the same bed at Chidru (one specimen). A single specimen I collected in the middle division of the Productus-limestone on the road between Vurcha and Uchâli.

Remarks.—The identification of the Indian shells here under consideration with Mons. de Verneuil's species is, I think, perfectly sure, and cannot well be doubted.

I had for comparison several specimens from Wosnesensk, belonging to the Hof-Mineralien Cabinet at Vienna. These specimens agree all very closely with the Indian shells. Every one of them is not so smooth as Verneuil's original, but in some the ribs on the lateral parts are as well visible as in the Indian specimens; also in size none of them attains the dimensions of de Verneuil's original. The beak, too, is often quite as much appressed as is the case in the Indian specimens. The only difference which could possibly be adduced is that the broadest part of the shell is slightly lower down towards the frontal region in the Russian specimens than in the Indian ones, so that the former appear slightly more triangular than the latter. This difference is, however, not sufficient to distinguish the two forms as separate species. It thus, I think, can be considered as a safely-ascertained fact, that the Russian species of the perm-formation occurs also in the Salt-range; and thus we have to add another species of permian age to the palæozoic fauna of the Salt-range.

It has been considered by many writers that *Cam. superstes* was nothing but a variety of *Cam. schlotheimi*, and I think that these writers, chiefly Geinitz, were perfectly right in taking what they considered to be *Cam. superstes* as identical with *Cam. schlotheimi;* Geinitz's figures at least certainly do not really represent what was indicated by Verneuil under the name of *Cam. superstes*. But the Russian as well as the Indian shells are something very different from *Cam. schlotheimi*, and form a characteristic and easily distinguishable species.

II. Sub-Order: HELICOPEGMATA, sive SPIRIFERACEA[1].

1. Family: *ATRYPIDÆ*, Dall.

Thanks to the admirable investigations of Messrs. Davidson and the Rev. Norman Glass, the whole mass of the spiral-bearing *Brachiopoda* has been so far elucidated that from having been among the most obscure fossils, they are now removed to the forms whose internal structure is in general more satisfactorily known than that of many other groups of shells. With these discoveries, however, and the consequent new classification of the spiral-bearing Brachiopods, a duty devolved upon the followers in palæontological research to pursue the path so ably opened out by those observers, and to make out, in a corresponding manner, at least the family characters in the shells that have to be described. Though this seems not much to be expected of a palæontologist, in point of fact the undertaking entails nearly insurmountable difficulties; the investigations require such an enormous amount of time, and it does not always depend upon the author of a work to dispose of what may be needed in that way, so that sometimes his observations must fall short of what might have been expected from him.

I regret to say that I am somewhat in this position. Though in the most important cases I have not failed to make out the most striking features of the interior of these spiral-bearing shells, yet similar investigations would have been very desirable in many cases where I was not in a position to execute them. There is not the slightest question that in *all* cases the internal features of these shells can be made out if only three or four specimens of a species can be spared for the purpose; but one must moreover have the necessary time at disposal, as these operations do not admit of any haste.

In the Salt-range the Brachiopods are not generally in so favourable a condition for these enquiries as the specimens on which the Rev. Norman Glass operated, entirely sparry specimens being extremely rare there. I have found altogether only two or three specimens with an entirely sparry matrix. The preservation of the Salt-range specimens is generally such that the external coating of the shell, and sometimes also the innermost layer, are silicified; between these layers the substance

[1] During the progress of the investigations bearing upon the description of the *Brachiopoda* of the Salt-range, it has become absolutely necessary to create some larger sub-divisions of the *Brachiopoda*, as the simple division into *Arthropomata* and *Lyopomata* appeared to be quite insufficient to bring out clearly the relations of the different groups. I therefore propose to distinguish three sub-orders for the *Arthropomata*, for which I wish to introduce the following designations:—

I. Sub-Order: KAMPYLOPEGMATA, sive TEREBRATULACEA, comprising the families: *Terebratulidæ*, *Thecideidæ*, *Rhynchonellidæ*, and *Stringocephalidæ*.

II. Sub-Order: HELICOPÆGMATA, sive SPIRIFERACEA, comprising the families: *Atrypidæ*, *Nucleospiridæ*, *Athyridæ*, and *Spiriferidæ*.

III. Sub-Order: APHANEROPEGMATA, sive PRODUCTACEA, comprising the families: *Strophomenidæ* and *Productidæ*.

of the valves is sparry, and the interior of the specimens is filled up with very hard, grey, argillaceous, silicious limestone. Of the interior organs generally, only the cardinal process of the dorsal valve and the parts of the crura immediately adjoining it are silicified; the spirals, however, and the loop are not so, but are preserved as sparry lamellæ enclosed in the grey limestone. Mr. Glass' process could therefore not be applied, and the mode in which I operated was generally the following: the ventral or dorsal valve, according to the side which I wished to expose, was carefully chipped off, then the matrix was smoothed down cautiously, with a sculptor's rasp, and occasional application of diluted acid, to near the spiral coils, and then diluted acid was applied with a brush, and an occasional touch of the rasp to remove the silicious parts, until the spirals and their connections became visible. At the same time it was necessary to cover the parts which were already sufficiently exposed, and had to be protected from the action of the acid, with sealing-wax or Canada balsam. This mode of proceeding requires a great amount of time, as the specimen must over and over again be dried and warmed for the application of the Canada balsam. With great patience and care at last sufficiently clear preparations can be obtained in this manner to arrive at a satisfactory determination of these fossils. The sparry lamellæ of the spiral cones and other parts come out then as dark lines on the grey matrix. The process of cutting the matrix with a knife was not applicable on account of the silicious ingredients of the rock, making it of a very unequal hardness at certain places, so much so that it was only by dissolving the calcareous matter that the silicious parts become sufficiently disintegrated for removal. After this digression on the mode of preservation of the Salt-range fossils, we may return to Mr. Davidson's new classification of the spiral-bearing *Brachiopoda*.

Among the four families, as distinguished by Davidson, the family *Atrypidæ* is the one which seems to be most nearly related to the *Rhynchonellidæ*, and I therefore quote it first. All the genera belonging to this family are characterised by spirals, which are turned with their apex either obliquely towards the middle of the dorsal valve, or which become so much shifted as to turn their apex from both sides inward towards the centre of the shell.

This general arrangement undergoes several modifications in different genera, and by these very natural groups are marked off, as has been indicated already by Davidson. I consider that the rank of sub-families may well be attributed to these groups.

The first group that has been distinguished is that of *Atrypa* proper, and it will form according to my views the sub-family ATRYPINÆ. This sub-family is characterised by high conical spirals with their apex directed obliquely towards the middle of the dorsal valve, and by a loop, consisting of a somewhat V-shaped shelly band, starting not far from the origin of the crura and directed with its apex towards the front of the shell. Two genera are quoted by Davidson as belonging to this division,—*Atrypa*, Dalm., and *Coelospira*, Hall.

Mr. Davidson's second division is made up of rather heterogeneous genera, and cannot be entirely accepted as a natural sub-family. Three genera, however, contained in this division form certainly a very good sub-family. They are—*Koninckina*, Suess; *Anoplotheca*, Sandberger; and *Koninckella*, Munier-Chalmas; and they may very well be united in a sub-family under the name of KONINCKININÆ. The sub-family is characterised by shelly spirals, coiled up nearly in one plane. A different type is represented by the genus *Thecospira*, Zugmayer; and whether *Davidsonia*, Bouchard, belongs altogether to the spiral-bearing Brachiopods remains, I think, still doubtful.

Davidson's third division, again, forms a well-defined natural sub-family, and, as such will most conveniently bear the name ZYGOSPIRINÆ. It is characterised by spiral coils, the apex of which is directed more or less towards the centre of the shell. The loop consists also of a somewhat V-shaped transverse shelly band, whose position is, however, variable, being sometimes placed not far from the origin of the crura, sometimes in the middle, and sometimes even near the frontal region. Three genera can be considered up to the present as belonging to this sub-family: *Glassia*, Davidson; *Zygospira*, Hall; and *Anazyga*, Davidson.

The geological range of the different genera has been indicated by Davidson.

The family *Atrypidæ* is not represented in the Salt-range. There is a little shell resembling *Productus lævis*, Davidson, that I always suspected of bearing spirals, and so to belong to the sub-family *Koninckininæ*, but a transparent preparation I made of one of the specimens shows no trace of spirals, and as the shell substance is also coarsely punctate, it seems probable that this little shell must be considered as a *Leptæna*.

2. Family: *ATHYRIDÆ*, Phillips.

This family does not contain a very large number of genera, and has been divided into two groups by Mr. Davidson. All the genera belonging to the family are characterised by spirals, the apex of which is turned towards the lateral parts of the shell. Otherwise the two groups exhibit rather essential points of difference, and must certainly at least be considered as forming two distinct sub-families. The first sub-family will best bear the name of MERISTELLINÆ; the name *Meristinæ* being inadmissible on account of the mistakes that might occur, owing to the genus *Meristina*, Hall, belonging to a quite different family. In the sub-family *Meristellinæ* the loop connecting the two spiral cones is of a very characteristic shape, having at its upper forked extremity two ring-shaped processes, and being altogether directed towards the apical part of the shell.

The second group has a quite different loop, and may thus be very well considered as forming another natural sub-family, which I shall introduce under the name of ATHYRINÆ. The sub-family is characterised by a loop directed towards the frontal part of the shell, but sending backwards towards the apex a forked pro-

cess to which are frequently attached accessory lamellæ. According to Davidson the following genera belong to this group: *Athyris*, M'Coy; *Kayseria*, Davidson; *Whitfieldia*, Davidson; and *Bifida*, Davidson.

The first of these sub-families is restricted to the silurian and devonian periods, and is not represented in the Salt-range; the second sub-family, on the contrary, has its chief development in carboniferous times and extends up into the trias.

It is only natural that this sub-family is largely represented in the Salt-range. I count about twenty species, which must, according to the views generally prevailing, be considered as belonging to the sub-family. These twenty species represent all the forms which have up to the present been united under the genus *Athyris* or *Spirigera;* but if we examine the shells attentively we can easily recognise that they can be separated in two groups. One group has a smooth shell, a strongly bent-over beak with a very small apical foramen, and internally a cardinal process in the dorsal valve, which is very prominent and divided in two parts, grown longitudinally together.

The second group is provided all over the surface of its shell with shelly expansions, which are sometimes fringed, sometimes entire; the beak is generally not much bent over, and is pierced at its apex by a large round foramen. Internally the dorsal valve is provided with a cardinal process, which is not prominent but flatly spread out and tripartite.

I consider these differences sufficient to distinguish between the two groups generically. The first of the groups is the type of a new genus which will bear the name of *Spirigerella*, Waagen; the second agrees exactly with what was described originally under the name of *Athyris*. I distribute the Indian shells among these two genera.

Sub-family: *ATHYRINÆ*.

Genus: SPIRIGERELLA, Waagen, n. gen., Syn. *Athyris*, pars auct.

The general outline of these shells is very characteristic, the chief peculiarity resting in the apical region, where the beak is so much bent over and appressed to the apex of the smaller valve, that the very small foramen which truncates the beak is entirely concealed. By this feature the shells belonging to this genus may be easily recognised externally. The name *Athyris* might well be applied to them without any inconvenience or contradiction of facts; but as the first species quoted by M'Coy in his genus is *Athyris concentrica*, a shell which cannot be counted among the forms I subsume under the present genus, the name *Athyris* must be reserved for shells similar to *Ath. concentrica*, and for the forms here under consideration a new name must be introduced.

The internal arrangement of this genus, so far as it could be ascertained, is to a certain extent identical with that of *Athyris*. There are two large spiral cones which fill the greater part of the interior of both valves, and are directed with their

apex towards the lateral parts of the shell. The primary stems of these spiral cones are united by a loop, which takes its origin on the upper third of these stems. There are two not very long lamellæ converging towards the middle, but the exact form of which could not be fully ascertained. They unite in the middle in a broad roof-shaped piece, which has been very completely exposed in some preparations. From the upper apical part of this roof-shaped piece a shelly lamella starts in a direction towards the apex and the ventral valve. It is apparently differently developed in different species; I found it in some species thin and similar to the ascending piece in *Ath. planosulcata* as figured by Davidson, and in others broadly lamellar, imitating the form of a septum. From the upper end of this ascending piece the accessory lamellæ take their origin by bifurcation. The latter are not very broad and of a normal size.

The distinguishing character between the interior arrangement of *Athyris* and the present genus lies in the cardinal process and the mode of attachment of the primary lamellæ to it.

The cardinal process is exceedingly large in the present genus, and extends a good way over the apex of the dorsal valve. It is very massive, and takes its origin on the bottom of the dorsal valve in two thick shelly pieces, further up in which the dental grooves or sockets are excavated. Between these pieces a conical groove is enclosed, with its apex directed towards the apex of the valve. This groove tapers very quickly and terminates in a round foramen forming the entrance to a very narrow canal, which pierces the substance of the whole cardinal process and terminates directly at the apex of the dorsal valve, forming there what has been called the visceral foramen. This foramen is, however, entirely concealed so long as the cardinal process is perfect; and opens in a deep fissure which separates the projecting cardinal process from the apex of the valve.

From the dental sockets the cardinal process passes vertically up, about parallel to the longitudinal axis of the shell, and forms an approximately rectangular shelly piece which projects far above the apex of the valve. On the ventral side this shelly piece is longitudinally divided into two parts by a low, prominent, furrowed ridge, and is sometimes provided at its upper end with two large, round, deeply-excavated grooves. On the dorsal side only a median longitudinal furrow is present.

The crura originate between the dental sockets at the base of the cardinal process. The points of insertion are sometimes connected by a sharp transverse ridge, sometimes not. The crura are straight and comparatively long. They are joined by the primary lamellæ of the spiral cones at an acute angle. The lamellæ then bend round in a sickle-shaped curve and descend to the point where the loop takes its origin.

Also in the ventral valve there are interiorly some distinguishing characters. The substance of this valve is generally extremely thick and heavy, chiefly in the cardinal region. The beak is strongly pointed and very much bent over. It is pierced at or just in front of its apex by a small foramen, which leads to a more or

less long narrow canal. Below the foramen and between the hinge-teeth extends a deeply-excavated triangular space, which serves for the reception of the apex of the smaller valve. This space is occupied by a kind of concave deltidium limiting the foramen at its lower side, and under which passes the canal forming the continuation of the foramen. This deltidium is for the greater part of its extent grown together with the substance of the shell, but at its lower end, where the canal opens within the valve, it is free for a short distance. The existence of such a deltidium is a very characteristic feature of the genus.

The genus is largely represented in the Salt-range, where I can distinguish not less than ten species, but it is very difficult to state whether any of them occurs out of India. One of them has been described by Davidson under the name of *Athyris subtilita*, Hall, but I do not think that the Indian shell belongs to Hall's species. The specimens from America, which I had occasion to study, as well as the great majority of figures published of the species, always show this shell to have a beak which is not entirely appressed, and pierced at its apex by a tolerably large round foramen; also the cardinal process, as figured by Meek and Worthen in the fifth volume of the Illinois reports, though perhaps generically identical, is on the whole very different; all of which characters forbid the identification of this shell with the Indian forms. A single figure may be quoted which is entirely and in every respect identical with the Indian shell; it is given by Derby from a specimen collected by him on the River Tapajos in Brazil. Though this specimen has been identified by Derby with *Athyris subtilita*, I think it belongs with the Indian specimens to a different species, which I shall describe under the name of *Spirigerella derbyi*.

This species is the prototype of a group of forms which occurs in the Salt-range, and within which three more species can be distinguished. They will bear the names of *Spirigerella prælonga*, W.; *Sp. hybrida*, W.; and *Sp. minuta*, W. All four species occur promiscuously in the middle and upper divisions of the Productus-limestone, and it is impossible to express an opinion as to their developmental connection.

One further group is typified by *Spirigerella grandis* (Dav.), W. Whilst the first group is characterised by a rather flat ventral valve and a simply-vaulted front-line, the second group has an extremely inflated ventral valve and a somewhat rectangular front-line. This group also is composed of four species: *Spirigerella grandis* (Dav.), W.; *Sp. media*, W.; *Sp. ovoidalis*, W.; and *Sp. fusiformis*, W. Of these species the first three occur in the middle, and somewhat more rarely in the upper division of the Productus-limestone, whilst the last is restricted to the upper division.

A third group is represented by two species characterised by flat valves and a very large apical angle. They are *Spirigerella numismalis*, W.; and *Sp. alata*, W. These two are decidedly in a developmental connection. The first occurs in the lower, the second at the limit of the middle and upper divisions of the Productus-limestone.

The species belonging to the genus will thus be grouped in the following manner :—

I.—Group of Spirigerella derbyi, W.
1. *Spirigerella derbyi*, W.
2. „ *prælonga*, W.
3. „ *hybrida*, W.
4. „ *minuta*, W.

II.—Group of Spirigerella grandis, W.
5. *Spirigerella grandis*, W.
6. „ *media*, W.
7. „ *ovoidalis*, W.
8. „ *fusiformis*, W.

III.—Group of Spirigirella numismalis, W.
9. *Spirigerella numismalis*, W.
10. „ *alata*, W.

It is very difficult to tell how this genus might have been developed out of other forms. That the genus is represented in Brazil has been said above, but whether the genus occurs also in Europe remains doubtful. Among the specimens figured by Davidson from carboniferous beds there is certainly none which could be considered to belong to the genus. Nevertheless forms do occur in Europe which probably must be considered as forming part of the present genus. Such forms have been mentioned by Count Verneuil and Beyrich. Verneuil says of *Athyris globularis*, Phill., that its beak is often quite pointed and the very small foramen nearly quite concealed, and Beyrich confirms this observation, and adds that the foramen is situated below the apex of the beak as in *Rhynchonella*. Thus it seems that there have been confounded two forms under the name of *Athyris globularis*, Phill., one of which might very well be the ancestor of *Spirigerella*. It may be left to the zeal of English observers to clear up these facts.

I.—Group of *SPIRIGERELLA DERBYI*, Waagen.

1. Spirigerella derbyi, Waagen, n. gen. et sp., Pl. XXXV, figs. 4—7, 9—13; Pl. XXXVII, figs. 11—13.

1862. *Athyris subtilita* (Hall), Davidson : Quart. Jour. Geol. Soc., Lond., Vol. XVIII, p. 28, Pl. I, fig. 8 (non fig. 7, non Hall).
1863. *Athyris subtilita* (Hall, Dav.), Koninck : Foss. Paléoz. de l'Inde, p. 33, pl. IX, fig. 8.
1867. *Athyris sp.* (*Athyris subtilita*, Hall), Verchère : Kashmir, the Western Himalaya, and the Afghan Mountains ; Jour. Asiat. Soc., Bengal, Vol. XXXVI, Part II, p. 210, pl. II, fig. 1, 1*a*.
1874. *Athyris subtilita* (Hall), Derby : Bull. Cornell Univ., Vol. I, No. 2, p. 7 (pars.), Pl. I, fig. 7.

The general form of this species is very variable, and it is barely possible to indicate all its variations by description. Generally its outline is considerably longer than it is wide; there occur, however, specimens in which the two dimensions are

nearly equal. The valves are both vaulted in every direction, but the dorsal valve decidedly more strongly so than the ventral one. There is a strong broad median fold on the dorsal valve to which an equal sinus corresponds in the ventral one, commencing not far from the apex.

The ventral valve shows a not very conspicuous curve in the longitudinal direction, and is nearly quite flat or only very little vaulted transversely. The beak is little prominent, tapering rapidly, sharply pointed and entirely bent over, so as to be firmly appressed to the apical part of the dorsal valve. The very small foramen situated just in front of the pointed apex of the beak is always concealed if the beak is perfect. A tolerably broad but not distinctly-marked-off false area extends on the dorsal side laterally from the beak.

The outline of the valve changes much with age, as it does not grow equally on all sides. The shapes it had successively exhibited can be distinctly traced by strong imbricating striæ of growth at irregular intervals on the valve. In adult specimens these become more numerous near the margin. During the young stage the changes are not considerable, but as soon as the shell is nearly full grown, the shelly zones added are very narrow on the lateral margins, but become suddenly broad in the region of the sinus, whereby a tongue-shaped process is formed, corresponding to the upward bend of the frontal line. This mode of growth takes place as soon as the sinus begins to be formed, but it is conspicuous only in full-grown specimens. The sinus reaches from the frontal line to about half the length of the shell. It is sometimes rather flat, sometimes more deeply impressed. The lateral margins are strongly bent up, so that the valve becomes somewhat cup-shaped.

The dorsal valve is in the longitudinal direction barely more strongly vaulted than the ventral one, but transversely its curvature is extremely marked, not, however, quite equally. From a kind of broad median crest the valve slopes down roof-like, in tolerably flat planes, and then suddenly bends down to the margin. On the apical part a considerable portion of this valve is concealed below the beak of the ventral one, but otherwise the ventral valve fits within the dorsal one in such a manner that the lateral margins of the dorsal valve cover up a more or less considerable breadth of the bent-up margins of the ventral one. The imbricating striæ of growth are present also in the dorsal valve at irregular distances, but the shelly zones marked off by them are of tolerably equal breadth in the lateral and frontal regions. The median fold is strongly prominent and broad, extending high up towards the cardinal region.

The substance of the shell is fibrous, but its surface is entirely smooth so long as it is intact. As soon, however, as it is even a little injured by the action of weathering, the texture becomes visible and the shell appears to be extremely finely striated radially.

The internal structure could be tolerably well made out in this species. The interior of the ventral valve is, however, less thoroughly known to me than that of the dorsal one. I think the shell figured, Plate XXXVII, fig. 13, represents the

interior of this valve. There is a very distinct deltidium present, below which the very narrow canal of the foramen passes. It is strongly concave, united for its greater extent with the substance of the shell, and extends from the foramen, which it limits at its lower side, down to the upper termination of the hinge-teeth. The whole valve is very strongly thickened, and most so in the cardinal region. In the middle a roundish oval space is hollowed out for the reception of the body of the animal. In the specimen I have for description I cannot distinguish the muscular impressions ; it is possible that they are like those figured by Davidson of *Athyris ambigua*, but I cannot say anything positive of it. A number of radiating vascular impressions are, on the contrary, very distinctly visible.

In the dorsal valve the general arrangement of the several parts is as indicated in the description ef the genus.

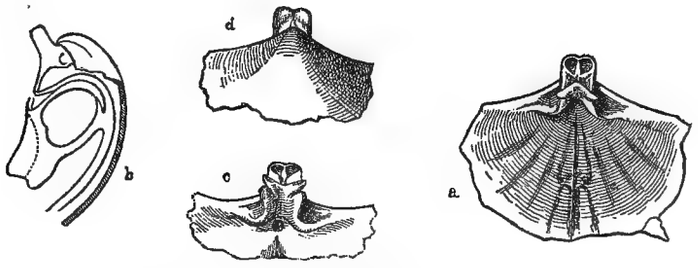


Fig. 5. *Spirigerella derbyi*, Waagen., n. gen. et sp. Specimens from the Cephalopoda bed of the upper Productus-limestone of Jabi : a, c, d, fragment of the dorsal valve showing the cardinal process ; a, internal view, the muscular impressions are distinguishable ; d, external view ; c, view from the frontal side, showing the entrance of the visceral canal ; b, the primary lamellæ and the loop of the same specimen, lateral view ; all figures strongly enlarged.

The specific peculiarities consist in two deep round grooves at the upper end of the cardinal process, and in a vertical lamella extending between the roof-shaped part of the loop and the ascending lamella which carries at its upper end the accessory lamellæ. Thus a partial vertical septum is formed, which does not, however, reach so far up as to appear between the recurving branches of the primary lamellæ of the spiral cones. Of the muscular impressions in the dorsal valve very distinct traces could be observed in a specimen from Káfirkot, in which the two pairs of impressions are one above the other along a little raised middle line, much in the manner as in *Athyris ambigua*.

The measurements of three specimens, No. I from Jabi, No. II from Káfirkot, and No. III from Musakheyl, are as follow :—

	I.	II.	III.
Entire length of the shell	27 mm.	25 mm.	25 mm.
Length of the smaller valve	24 „	23 „	22·5 „
Entire breadth of the shell	27 „	24·5 „	23 „
Thickness of both valves	18 „	17 „	16 „
Apical angle of the larger valve	110°	97°	96°
„ „ of the smaller valve	112°	108°	102°

The specimen No. I is the largest that has been observed by me.

Varietas : ACUTEPLICATA, Waagen : Pl. XXXV, figs. 10, 11; Pl. XXXVII, fig. 11.

This form shows some differences from the typical shapes of *Spirigerella derbyi*, which I wish to indicate, but which I consider barely sufficient to distinguish the shell as a separate species, as every degree of intermediate form exists in great abundance between the two. The present variety does not generally grow so large as the typical form, and is chiefly distinct from it by a flatter ventral valve, bearing a very deeply impressed sinus, which reaches up for nearly two-thirds of the length of the valve, and causes the dorsal valve to ascend in a prominent narrow fold.

Of the internal structure of this variety nothing is known to me. Its geological distribution is the same as that of the typical form.

Locality and geological position.—This species is, next to the *Producti* of the '*costatus*' group, the most common shell of the Salt-range. I had more than three hundred specimens of it for description. It occurs as well in the middle as in the upper division of the Productus-limestone, but has not been observed up to the present in the lower division. It is represented in the collection from the middle division of the Productus-limestone, from the Chittawán (8 sp.), from Swás (30 sp.), from the mountains east of Katwáhi (9 sp.), from Musakheyl (9 sp.), from the Crinoid beds of Virgal (9 sp.), from the road between Vurcha and Uchál (12 sp.), from Vurcha (2 sp.), from the Bazarwán (7 sp.), from Morah (5 sp.), from Káfirkot (31 sp.), and from Budikheyl (5 sp.).

From the upper division it is represented from Khundghát (60 sp.), from the Cephalopoda bed of Jabi (18 sp.), from the same bed at Chidru (8 sp.), and from the same locality above the Cephalopoda bed (5 sp.), from the section at the village of Khura (27 sp.), and from west of that village (16 sp.), from Nanga (2 sp.), from Katwáhi (26 sp.), from Kufri (12 sp.), from Kálabágh (10 sp.), from Káfirkot (3 sp.), from Káfirkot north (10 sp.), from the Paránga Kass (2 sp.), and from Sheik Budín (2 sp.).

From these lists it appears that the species generally occurs somewhat more frequently in the upper than in the middle division of the Productus-limestone, but the difference is not much.

Remarks.—As this species has been generally considered as identical with *Athyris subtilita*, Hall, it requires some words of explanation why I cannot agree with this opinion. The very extensive materials of this species enable me to judge with great certainty about the mode and degree of variation that occurs in these Indian shells, and I can state with all possible exactitude that a large round foramen, as is exhibited certainly in the majority of specimens of *Athyris subtilita*, is never present in the Indian form. Among the more than three hundred specimens accessible to my observation, there is not a single one that bears such a foramen. This is at once a striking difference between the two species. The best figures that have been published up to the present of American specimens of *Athyris subtilita* are apparently

those given by Geinitz in his work on Nebraska; and they show a tolerably large foramen truncating the apex of the beak. But also all the other figures accessible to me, as well as some specimens I have received for comparison, show such a foramen. The only figures that exhibit a configuration of beak as in the specimens from the Salt-range are the drawing given by Davidson of a specimen from Kashmir, and the photograph obtained by Derby of a specimen from Brazil. In Brazil, however, the two forms seem to occur, as Derby in his description of the species says: "Beak prominent, rounded, strongly incurved over that of the dorsal valve, truncated by a large circular foramen, incomplete in front, below which is a large triangular fissure, filled by the beak of the dorsal valve and entirely concealed, when the valves are united." This description was decidedly made from a specimen of the true *Athyris subtilita*, whilst the photograph, Pl. I, fig. 7, represents a shell identical with our *Spirigerella derbyi;* and it can be distinctly seen in the photograph that the small foramen visible in the figure is due only to a slight injury to the apex of the beak, otherwise the foramen would be entirely concealed as in the Indian specimens.

I thus think myself justified in distinguishing specifically between the *Athyris subtilita* and the Indian shells; all the more as the former seems to possess also no concave deltidium below which the canal of the foramen passes.

Whether the specimens from the Himalaya are specifically identical with those from the Salt-range I am unable to decide.

2. SPIRIGERELLA PRÆLONGA, Waagen: n. gen. et sp., Pl. XXXV, fig. 8; Pl. XXXVII, fig. 10.

This species in its general outline resembles very much the preceding one, but is more elongately oval, so that its length far exceeds its breadth. The ventral valve is flat, the dorsal one inflated, with a high median fold. The species does not grow very large.

The ventral valve is well vaulted in a longitudinal direction, but nearly quite flat transversely. The sinus is rather deeply impressed and extends up for two-thirds of the length of the valve. The beak is not very prominent, firmly pressed to the dorsal valve, tapering rapidly, and completely bent over so that the foramen is quite concealed. On each side of the beak is a very distinct false area, marked off from the remainder of the shell by not very sharp but yet rather conspicuous carinæ, which originate at the apex of the beak and extend down to the end of the hinge-line. I regret to say that this carinated condition of the beak has not been sufficiently well expressed in the figure, Pl. XXXVII, fig. 10*c*.

The dorsal valve is longitudinally less strongly vaulted than the ventral one, but in a transverse direction its bend is very strong and about parabolical in outline. The median fold is not marked off from the remainder of the surface, but forms only the highest median elevation of the general parabolic curve.

The surface of both valves shows strong imbricating striæ of growth, which are

arranged in the same manner as in the preceding species, causing in the ventral valve in the region of the sinus a prominent tongue-shaped shelly part to be formed. Otherwise the surface of the shell is perfectly smooth; and no fibrous structure becomes visible by the act of weathering.

Of the internal characters only those of the ventral valve are known to me. The beak of the specimen I have for description is somewhat weather-worn, and no quite exact observation is possible, but it seems to have a concave deltidium under which passed the canal of the foramen. The whole region of the beak is strongly thickened and callous. The most striking feature of the internal surface of the ventral valve consists, however, in a thick rounded prominence in the middle, not very far from the beak, and which represents apparently a strangely transformed septum. Below this prominence, extending towards the frontal margin, is a deep pear-shaped impression, having at its upper end a yet deeper small oval groove. Laterally there are two large elongated impressions, which are bipartite, a line of separation traversing them about the termination of the median prominence. This line has been omitted in the drawing, Pl. XXXV, and the impressions are too strongly marked at their lower extension. Traces of radiating vascular impressions are also visible. It seems scarcely possible to give an interpretation of the different impressions described above.

The interior of the dorsal valve is not known to me.

The dimensions of a full-grown specimen from Jabi are as follow:—

Entire length of the shell	28 mm.
Length of the smaller valve	25 „
Entire breadth of the shell	21 „
Thickness of both valves	17 „
Apical angle of the larger valve at the apex, decreasing to 75° lower down	95°
„ „ „ smaller valve	90°

Locality and geological position.—This is a very rare species, only three specimens of it have been detected up to the present, which were found by myself in the upper division of the Productus-limestone. Two of them came from the Cephalopoda bed of Jabi and one from the section west of Khura.

Remarks.—In its external form this species is very nearly related to *Spirigerella derbyi*, and from its external form alone the specific separation from that species would barely be granted by other naturalists. The peculiarities of the internal side of the ventral valve are, however, too striking to suppose that this shell might form only a sample of the great number of varieties which together form the species *Spirigerella derbyi*.

Nevertheless there are also in the external form certain characters by which the present species can be recognised without a knowledge of its interior. These characters consist in the elongated shape of the shell, the flatness of the ventral valve, and the carinæ that extend from the apex of the beak down to the end of the hinge-line.

To *Athyris subtilita* the present species is less nearly related than the preceding one.

3. SPIRIGERELLA HYBRIDA, Waagen: n. gen. et sp., Pl. XXXVII, figs. 17—19.

The general outline of this species is oviform, nearly globular, with extremely inflated valves, overlapping each other along their margins. Otherwise the shell is not dissimilar to *Spirigerella derbyi*, but never attains nearly so large a size.

The ventral valve is strongly vaulted in every direction, but its longitudinal curve is somewhat stronger than the transverse one. The valve is strongly cup-shaped, the lateral and frontal margins being highly and angularly bent up. The bent-up part of the margins is, however, nearly quite concealed in complete specimens, as these parts are entirely covered up by the margins of the dorsal valve. The beak is prominent and very strongly inflated, not entirely bent over, and abruptly tapering. The very small foramen is situated at the apex of the beak and not entirely concealed. On both sides of the beak there is a tolerably broad false area, which is sometimes marked off from the remainder of the shell by slightly indicated ridges, extending from the apex of the beak to the end of the hinge-line. These ridges are, however, often entirely absent. In the frontal line there is a high, tongue-shaped, shelly prominence, which causes the front-line to ascend in a narrow curve. The sinus is barely at all developed in some specimens; in others it is present.

The dorsal valve is very strongly inflated and vaulted in both directions. Longitudinally the greatest curve of the valve is situated in the apical region, lower down towards the front, the outline becomes nearly straight in a lateral view of the shell. Transversely the curve is very equal and strong, and forms nearly a semicircle. The median fold is strong and prominent, but only distinctly marked in the frontal region.

The surface of the shell is ornamented, as in other species of the genus, by strong imbricating striæ of growth, which occur at irregular distances, but are more numerous near the margins. Otherwise the surface of the shell is smooth.

Of the internal characters only those of the ventral valve are known to me. The deltidium is very little developed in this species. There is a distinct foramen at the apex of the beak, which is limited at its lower part by a shelly piece, which represents apparently something like a deltidium, but within the valve I cannot find any opening to indicate the entrance of the foraminal canal. Also in this species the substance of the shell is very much thickened in the cardinal region. This thickening suddenly decreases about the termination of the hinge-line, but in the middle a part of this thickening projects further out and terminates in two low ridges which surround an indistinct pear-shaped groove; no other impressions can be recognised in the specimen I have for description. The hinge-teeth are very little developed in this species, and seem in some specimens to be nearly obsolete.

The dimensions of the largest specimen known to me, from Kálabágh, are as follow :—

Entire length of the shell	20	mm.
Length of the smaller valve	18	„
Entire breadth of the shell	15	„
Thickness of both valves	15	„
Apical angle of the larger valve	100°	
„ „ „ smaller valve	95°	

Locality and geological position.—This species has its chief development in the upper division of the Productus-limestone, but commences already in the topmost beds of the middle division. It has been collected by myself west of Khura (two specimens), and in the section at the village itself in the yellow sandy marly beds of the upper division (three specimens), as well as in the thin-bedded grey limestones at the top of the middle division (one specimen). Also in the mountains east of Katwáhi I collected the species in the upper division (four specimens). Mr. Wynne brought the species from the upper division of Khund Ghát (two specimens), and Chidru (one specimen), and from the limit between the middle and upper divisions from Kálabágh (one specimen).

Remarks.—The great inflation of the valves of this species make its distinction from similarly-sized specimens of *Spirigerella derbyi*, W., not very difficult. The internal side of the ventral valve shows a certain typical similarity to the same valve of *Spirigerella prælonga*, W., in so far as in both species a kind of a median septum exists. The shape of the septum in the two species is, however, very different.

4. SPIRIGERELLA MINUTA : Waagen, n. gen. et sp., Pl. XXXVII, figs. 14—16; Pl. XXXVIII, figs. 3, 4.

It is not easy to distinguish this species either from *Spirigerella hybrida* or from young specimens of *Spirigerella derbyi;* yet these little shells have something about them by which they are easily recognised among a number of shells, and which suggests the probability of a distinct species.

The general outline is somewhat variable, but generally more or less rhomboidal, the greatest breadth being situated about in the middle of the shell ; in some cases, however, it is somewhat lower down. The valves are not much inflated, the ventral valve generally considerably flatter than the dorsal one, but the latter bears a very sharp and high median fold. The size of the species remains always small.

The ventral valve is vaulted in a longitudinal direction only, transversely it is quite flat or even excavated, the margins are not bent up, but the frontal part is much produced, causing the frontal line to make a high narrow bend upward. The beak is small, not prominent, entirely bent over so as to quite conceal its foramen. The false area is not very broad, and very indistinctly marked off from the remainder of the shell. The sinus of this valve commences not far from the beak, and is mostly deeply impressed.

The dorsal valve is vaulted in both directions, but longitudinally its bend is only strong in the apical region. Transversely the valve is more strongly vaulted, but also in this direction the bend is generally moderate. The median fold is very prominent, and commences not far from the apex of the valve.

The surface of the shell is smooth, except some imbricating striæ of growth which are strongly marked from distance to distance.

The interior of this species is not known to me.

The dimensions of two specimens from Jabi, No. I, an exceptionally large specimen, No. II, the typical form, are as follow :—

	I.	II.
Entire length of the shell	17 mm.	12·5 mm.
Length of the smaller valve	15 „	11 „
Entire breadth of the shell	14·5 „	11 „
Thickness of both valves	10 „	8 „
Apical angle of the larger valve	96°	85°
„ „ „ smaller valve	102°	90°

Locality and geological position.—The species begins already in the middle division of the Productus-limestone, but is rather rare there in the middle and lower zones, becoming more numerous in the top-beds. The greatest number of specimens was collected in the upper division.

I collected the species in the middle region of the middle division of the Productus-limestone at one locality, in the section at Khura (3 sp.) and in the same section in the top-beds of the middle division (4 sp.). In a similar position to the latter the species has also been found by myself in the mountains east of Katwáhi (1 sp.), and by Mr. Wynne at Musakheyl (1 sp.) and at Kálabágh (2 sp.). In the upper division of the Productus-limestone the species has been collected most numerously by myself at Jabi in the Cephalopoda bed (14 sp.).

Remarks.—This species is most nearly related to *Spirigerella hybrida* and *Spirigerella derbyi*. From the former it can be distinguished by much less inflated valves; and from similarly-sized specimens of the latter by its more elongated shape, more prominent and narrower dorsal fold and flatter ventral valve, which bears a more deeply impressed sinus.

II.—Group of *SPIRIGEREL LA GRANDIS*, Waagen.

5. Spirigerella grandis (Davidson), Waagen: Pl. XXXVI, Pl. XXXVII, fig. 1.

1862. *Athyris subtilita*, Hall, var. grandis, Davidson: Quart. Journ. Geol. Soc., Lond., Vol. XVIII, p. 28, Pl. I, fig. 8 (non fig. 7).

1863. *Athyris subtilita*, Hall, var. grandis (Davidson), Konninck: Foss. paléoz. de l'Inde, p. 33., Pl. IX, fig. 8.

The general outline of this species is elongately oval with very strongly inflated valves, and a prominent median fold on the dorsal side, which is rectangular or slightly biplicate. The species attains very considerable dimensions.

The ventral valve is very strongly inflated with a tolerably equal curve throughout its length, and with the same equal curve also in the transverse direction. The beak is not very prominent, pointed and very quickly tapering. It is entirely bent over and firmly appressed to the apical part of the dorsal valve, so that the very small foramen is entirely concealed. The false area on both sides of the beak, though rather large, is yet very indistinct, and not marked off in any way from the remainder of the shell. The sinus is well developed and begins already not very far from the apex, extending for about two-thirds of the entire length of the valve. The valve is ornamented at irregular distances by strong imbricating striæ of growth which are generally most numerous near the margins. The latter are generally more or less bent up, chiefly in full-grown specimens, and the bent-up part is then covered by the margins of the dorsal valve, so that the valves overlap each other more or less. The frontal part of this valve is produced in a nearly rectangular lappet.

The dorsal valve is about equally strongly vaulted as the ventral one, and longitudinally as well as transversely its curve is very equal. A rather large part of its apical region is concealed below the beak of the ventral valve. The median fold of this valve is not so strongly marked as the sinus on the other, and thus also not very strongly prominent. It is more distinctly developed only in the frontal region, and even here it is mostly only conspicuous by the bending up of the frontal line. In some cases it bears a depression on the top, and thus becomes biplicate in a slight degree. This valve also bears at irregular intervals strong imbricating striæ of growth, which are generally more numerous near the margins. These latter hang down laterally over the margins of the ventral valve in full-grown specimens, thus enveloping them more or less.

The substance of the shell is fibrous in its structure, and its external surface, excepting the imbricating striæ of growth, is entirely smooth.

The interior characters of this species are tolerably well known to me. The ventral valve is of a truly enormous thickness in the apical region, whence its thickness gradually tapers towards the frontal margin. The foramen is not larger than the point of a pin, and the canal which communicates with it not wider than a thread. The foramen opens immediately under the apex of the beak, and is situated at the upper extremity of a deeply excavated triangular space, which serves for the reception of the apical part of the smaller valve. This space is occupied by a deeply concave triangular shelly plate which is firmly united for its greater extent with the substance of the valve, and is free only along its lower margin, and where the canal of the foramen passes under it. It shows striæ of growth parallel to its lower margin. I consider this plate as a kind of deltidium. The canal of the foramen opens internally under this plate, and its internal aperture cannot be seen except in a longitudinal section of the valve. The muscular impressions are situated nearer to the beak than to the frontal margin. They occupy a roundish space, which is divided in the middle longitudinally by a raised line with two symmetrical parts. Altogether four impressions can be distinguished. The larger

pair, which is situated below and laterally, belongs very likely to the divaricators; the smaller pair, which is above and partly included between the foregoing, very likely represents the adductors. All round the central muscular impressions originate a number of radiating, simple, vascular impressions, which disappear towards the margin of the valve without becoming ramified.

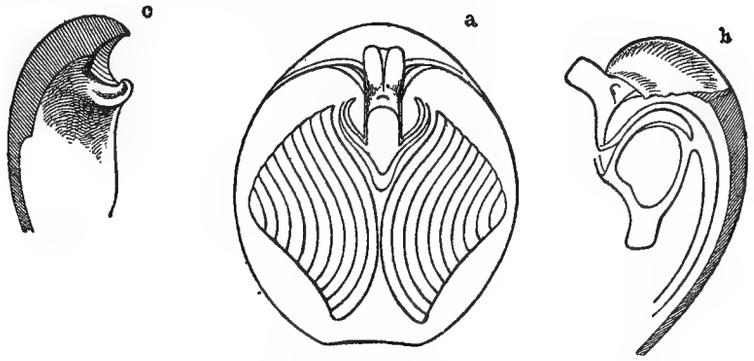


Fig. 6. *Spirigerella grandis*, Waagen, n. gen. et sp. Specimen from the middle Productus-limestone of Musakheyl: a, ventral view of the spirals, natural size; b, lateral view of the loop and primary lamellæ, slightly enlarged; c, section through the ventral valve, showing the canal of the foramen and the deltidium.

In the dorsal valve the most striking feature is the enormous massive cardinal process, which projects far above the apex of the valve, and bears at its base the crura for the support of the spiral cones. This process is distinct from the same part of *Spirigerella derbyi* by elongated not very deeply impressed grooves at its upper termination, by the absence of a transverse prominent ridge at its base connecting the origin of the crura, and on the whole by its more massive structure. The crura are tolerably long and quite straight. They are laterally joined by the primary lamellæ of the spirals, which first of all make a sickle-shaped bend, and are rather thick in this part of their extent; the accessory lamellæ of the loop approach them very closely. The loop is in general of the ordinary shape occurring in Athyris, but it could not be made out with perfect certainty whether there may not exist a septum-like lamella on the roof-shaped part of the loop, as in *Spirigerella derbyi*; it seemed, however, to be absent in the specimens I had occasion to study.

The substance of the cardinal process is pierced by a visceral canal which opens with a very small foramen at the apex of the valve in a deep furrow extending between the apex and the cardinal process. The muscular impressions occupy a long narrow central zone on both sides of a slightly raised median line. The line of demarcation between the upper and lower pair is very indistinct. It seems that both pairs are of about equal length, and that the point of separation lies about in the middle of the length of the whole impression. On both sides of this median impression originate radially arranged simple vascular impressions which disappear again without becoming ramified.

The species changes its shape very much with age. Young specimens up to a diameter of 30 and more millimetres appear thickly lenticular, with a front-line which is nearly straight, barely at all elevated.

The dimensions of two full-grown specimens, Nr. I from Chidru, Nr. II from Musakheyl, are as follow:—

	I.	II.
Entire length of the shell	41 mm.	40 mm.
Length of the smaller valve	36 „	34 „
Entire breadth of the shell	36 „	31 „
Thickness of both valves	29 „	32 „
Apical angle of the larger valve	90°	95°
„ „ „ smaller valve	110°	109°

Locality and geological position.—This species is not nearly so common as the *Spirigerella derbyi*, with which it has been united by Davidson under the name of *Athyris subtilita*. It is a species which is almost entirely restricted to the middle division of the Productus-limestone. Among 46 specimens preserved in the Salt-range collection, there is only a single specimen from the upper division. The species is most numerous in the Crinoid-beds of the middle division at Virgal, where I collected within a quarter of an hour ten specimens of it. It is also not rare at Swás, at which locality eight specimens were collected by Dr. Oldham, and at Musakheyl, where it has been found by Dr. Warth and Mr. Theobald, together fourteen specimens. Further, it has been collected in the middle division by myself on the road from Vurcha to Uchâli (five specimens), by Dr. Oldham at Chidru (five specimens), by Mr. Wynne at Budikheyl (one specimen) and at Kálabágh (two specimens).

The only specimen from the upper division of the Productus-limestone was collected by myself at Chidru in the Cephalopoda bed.

Remarks.—The name under which this shell has been known for a long time is *Athyris subtilita* var. *grandis* (Dav.); and I have to explain why I have not retained this denomination. It cannot be denied that in its general form the present species shows a very great similarity to *Athyris subtilita*, chiefly to those varieties which occur in Europe, and which have been figured by Davidson and Koninck, only the larger size of the Indian specimens being somewhat remarkable. On closer comparison, however, we find that between the European and Indian shells the same difference prevails as exists between *Athyris subtilita* and *Spirigerella derbyi*, which is, that the foramen is extremely small and entirely concealed in the Indian form, whilst it is tolerably large and entirely exposed in the European shells. This condition of the foramen in *Spirigerella grandis* is not a character that appears only with age, as might be supposed, when the shell acquires a monstrous thickness; the character is already present in the very youngest specimens, and is never absent; I consider it perfectly sufficient to distinguish specifically between the Indian and European shells.

The present species also has, however, always been united by Davidson with the shell I have described above under the name of *Spirigerella derbyi*. There is no doubt a similarity of type between the two species, nevertheless they can readily be distinguished when sufficient materials are available. It needs only a comparison of similar-sized specimens of the two species to be immediately struck with the

differences that exist. If we consider the specimen of *Spirigerella grandis* figured in Pl. XXXVI, fig. 4, and compare it with the equal-sized specimen of *Spirigerella derbyi* figured in Pl. XXXV, fig. 5, it is immediately apparent that the former species is much more circular in its outline, lenticular in its general form, and bears a much less developed median fold in the dorsal valve than the latter. Like differences will be observed if we compare, for instance, fig. 1, Pl. XXXVII, with fig. 12 of Pl. XXXV. From this it appears that the final shape of the shell is much later developed in *Spirigerella grandis* than in *Spirigerella derbyi*. This is one of the distinguishing characters. Another consists in the much greater inflation of the ventral valve, and lastly the promiment frontal part of the ventral valve is more or less rectangular, and sometimes even bears an indentation in the middle.

It appears to me that these characters are sufficient to distinguish the two forms, and thus *Spirigerella grandis* seems to form a characteristic separate species.

6. SPIRIGERELLA MEDIA, Waagen: n. gen. et sp., Pl. XXXVII, figs. 6-9.

The general outline of this species is elongated pentagonal or more or less oval, with very strongly inflated valves, and a deep sinus in the frontal region of the ventral one. The beak bears at its apex a very small but nearly always visible foramen.

The ventral valve is very strongly inflated, but its bend is not very equal, being stronger in the region of the beak and rather flat in the frontal region. The sinus is deeply excavated but short, not reaching far up towards the beak. The beak is thick, little promiment, and not entirely bent over, pierced at its extremity by a very small foramen, which is generally visible as the beak is not firmly appressed to the dorsal valve. The false area is small and very indistinct.

The dorsal valve is even more strongly inflated than the ventral one. The greatest inflation is in the apical region, and from there the valve gradually tapers towards the frontal line. From this configuration of the two valves it results that the frontal line is sharp. The median fold is barely at all indicated in the dorsal valve.

The imbricating striæ of growth are not strongly marked, though they are present also in this species.

The inside of this species is very imperfectly known to me. On Pl. XXXVII, fig. 6, I have figured a piece of a much-weathered ventral valve, which shows the inside, and which apparently belongs to this species. Its most remarkable feature is, that the canal of the foramen, passing below the deltidium, is bifid at its lower extremity from the presence of a small septum in the middle. Further up it is entirely closed, and the foramen at the apex of the valve terminates blind. Of the very deep muscular impressions, only the uppermost margin is preserved on the piece, and is visible as a very deep median excavation at the lower end of it. The other impressions visible on this piece cannot be made out just now as to their nature.

The interior of the dorsal valve is entirely unknown to me.

The dimensions of a full-grown specimen of this species from Khura are as follow:—

Entire length of the shell	27 mm.
Length of the smaller valve	25 „
Entire breadth of the shell	24 „
Thickness of both valves	21 „

Apical angle of the larger valve from 95° at the apex to 60° lower down.
„ „ „ smaller valve 112°.

Locality and geological position.—This species, like the preceding one, is chiefly represented in the middle division of the Productus-limestone; but it extends also, becoming somewhat rarer, into the upper division. In the middle division it has been met with by Mr. Wynne in the Bazarwán (eight specimens), at Vurcha, (three specimens), at Swás (two specimens), and in the Amb valley (one specimen). By myself it has been collected in the upper region of the middle division in the mountains east of Katwáhi (16 specimens), and in the upper division of the Productus-limestone in the section near Khura (one specimen).

Trans-Indus the species has been found by Mr. Wynne at the limit between the middle and upper divisions at Kálabágh.

Remarks.—The form which is most nearly related to the present species is *Spirigerella grandis*, W., and perhaps it would be advocated by many naturalists that the two forms should be considered as belonging to one and the same species. But after a careful study of the specimens contained in the Salt-range collection, I came to the conclusion that two species can properly be distinguished. A character which is not very valuable for specific distinction, but which is very conspicuous, is the smaller size constantly exhibited by the specimens belonging to *Spirigerella media*. At a size at which the *Spirigerella grandis* is yet quite lenticular and barely with any sinus in the ventral valve, the present species is already full-grown, with a strong and deeply impressed sinus in the ventral valve. Other points of difference consist in the somewhat pentagonal shape; different inflation of the valves, which is strongest in the apical region; and in the strange configuration of the beak, which is thick and quickly tapering, and at the same time little bent over so as to expose the small terminal foramen.

A large round foramen, as is characteristic for *Athyris subtilita*, never occurs in this species.

7. Spirigerella ovoidalis, Waagen: n. gen. et sp., Pl. XXXVII, figs. 2—5.

The general outline of this species is ovoid, with moderately inflated valves, very little developed median sinus and fold, and a small beak. The species never attains considerable dimensions.

The ventral valve is moderately inflated, with a very equal curve throughout, longitudinally as well as transversely. There is barely a trace of a sinus, though the frontal line is rather strongly bent up. This curve of the frontal line is solely caused by a shelly prominence in the frontal region of this valve. The beak is small,

not very prominent, and strongly incurved, so as not to show the very small foramen immediately below the apex, except in the case when the beak is somewhat injured. The false area is very small and quite indistinct.

The dorsal valve is longitudinally slightly less strongly vaulted than the ventral one, but transversely its curve is rather stronger than that of the opposite valve. A median fold is present, but is developed only in adult specimens, when it is limited entirely to the frontal region. It never becomes very prominent.

The surface of the shell is remarkably smooth, the imbricating striæ of growth occurring rarely, except near the margins of the valves.

The interior of this species is entirely unknown to me.

The measurements of a full-grown specimen from Kálabágh are as follow :—

Entire length of the shell	24 mm.
Length of the smaller valve	21·5 „
Entire breadth of the shell	20 „
Thickness of both valves	16·5 „
Apical angle of the larger valve	89°
„ „ „ smaller valve	107°

Locality and geological position.—This is a rare species; only eleven specimens of it have been collected. It is chiefly numerous in the transitional beds between the middle and upper divisions of the Productus-limestone, and extends up into the upper division. In the transitional beds it has been collected by Mr. Wynne, Trans-Indus, at Kálabágh (two specimens), and in the Paránga Kass (four specimens). By myself it has been found in the same geological position in the section at Khura (three specimens), and in the upper division of the Productus-limestone west of Khura (two specimens).

Remarks.—Though this species, through its strongly inflated ventral valve, belongs to the group of *Spirigerella grandis*, yet by its general configuration it approaches more closely to *Spirigerella derbyi*, W., than to any other species. The chief differences between the two forms consist in the more strongly vaulted ventral valve, the entire absence of any kind of a median carination in the dorsal valve, and the less strongly bent-up frontal line. From *Spirigerella grandis* and *media* this species is immediately distinguishable by its much smaller size, but besides this it is also much more regularly and elongately oval, and has a differently vaulted dorsal valve.

8. Spirigerella fusiformis, Waagen: n. gen. et sp., Pl. XXXVIII, figs. 5, 6.

This species is remarkable by its very elongated and laterally compressed form. Its valves are at the same time very much inflated, so that the thickness of the shell exceeds its breadth. There is a very strong rectangular median fold.

The ventral valve is strongly curved in the longitudinal direction, and the bend is tolerably equal, perhaps slightly more strong in the apical than in the frontal region. Transversely the bend of this valve is very strong in the apical region, but

as soon as the sinus begins to appear the valve becomes nearly flat in the transverse direction. The frontal part is very much produced and causes the frontal line to ascend prominently. The outline of the produced frontal part is approximately rectangular. The beak is not very prominent, strongly bent over, but not so much as to conceal the small foramen which pierces it just at the apex. The false area is very small and indistinct.

The dorsal valve is in the longitudinal direction as strongly curved as the ventral one, and in the transverse direction is much more so. The median fold is strongly developed and angular, limited on both sides by flat furrows. It is nevertheless restricted to the frontal region, not reaching further up than one-third of the length of the valve.

The surface of the shell is ornamented by strong, distant, imbricating and sometimes lamellar striæ of growth, which become heaped together in more or less great numbers near the margins of the valves.

The interior of this species is entirely unknown to me.

The measurements of a full-grown specimen from Vurcha are as follow :—

Entire length of the shell	30·5 mm.
Length of the smaller valve	27 „
Entire breadth of the shell	19·5 „
Thickness of both valves	23 „
Apical angle of the larger valve	80°
„ „ „ smaller valve	90°

Locality and geological position.—This species is very rare and entirely restricted to the upper division of the Productus-limestone. It has been collected by myself in the Cephalopoda bed of Chidru (two specimens), and Mr. Wynne has brought the species from Khund Ghát (two specimens) and from Vurcha (one specimen).

Remarks.—The elongated narrow shape and great inflation of the valves are characters that distinguish this species readily from all the others of the same genus. Only with juvenile specimens some doubt may exist; in Pl. XXXVIII, fig. 5, I have figured a specimen which perhaps might represent the young state of the present species. It is very difficult to class such young specimens, and in many cases one can never arrive at a satisfactory determination of them. Though, however, such doubts exist about the young, yet the adult ones, when the definitive characters are developed, can easily be distinguished, and they must, I think, be considered as forming a well-established species.

There exists also a certain resemblance of the adult specimens of this species to *Athyris subtilita* as it occurs in Europe; but the great narrowness and inflation of the valves in the Indian shell make a distinction from the European form not very difficult.

III.—Group of *SPIRIGERELLA NUMISMALIS*, Waagen.

9. Spirigerella numismalis, Waagen: n. gen. et sp., Pl. XXXVIII, figs. 1, 2.

The general outline of this species is broadly oval or nearly circular, as long as it is broad; the valves are rather flat and depressed. The species never attains considerable dimensions, but remains always small.

The ventral valve is in both directions very little arched, nearly quite flat. It has a slightly impressed sinus, which is, however, entirely limited to the frontal region. The latter is little produced, and causes the frontal line to ascend slightly. The beak is not prominent, thin, and not much bent over when entirely preserved, and quite straight when the apex is broken. The foramen is always visible, small and not entire, apparently shut in on its lower side by a concave deltidium, but there is no specimen in which this is clearly exhibited. If the beak is injured the foramen appears large and round. On both sides of the beak extends a broad and flat distinct false area, which is marked off from the remainder of the shell by obtuse not very distinct ridges extending from the apex of the beak to the end of the hinge-line. The latter slopes very little on both sides from the middle, nearly straight.

The dorsal valve is only slightly more strongly vaulted in the longitudinal direction than the ventral one. Transversely the bend is, however, much stronger, and in some specimens an obtuse median carina can be observed, which extends from the apex to the frontal margin, forming there the median fold. In other specimens this carina is very indistinct and the median fold seems to be limited solely to the frontal region. The median fold is, however, never very prominent. The apex of the dorsal valve is strongly incurved and partly concealed under the beak of the larger valve, being inserted in a triangular slit situated under the beak of the latter valve, and which is apparently filled up by a concave deltidium.

The surface of the shell in this species, as well as in all the other species of *Spirigerella*, is ornamented by strong, distant, imbricating striæ of growth, which are very numerously heaped together near the margins, whereby these become obtuse.

I am not acquainted at all with the interior of this species; the black coaly, sometimes very hard and sometimes friable, sandstone in which all the specimens are contained did not allow of any investigation as to their internal structure.

The measurements of two specimens from Amb are as follow:—

	I.	II.
Entire length of the shell	16 mm.	11 mm.
Length of the smaller valve	15 „	10 „
Entire breadth of the shell	15·5 „	11·5 „
Thickness of both valves	9 „	6 „
Apical angle of the larger valve	115°	120°
„ „ „ smaller valve	120°	124°

The specimen No. I is the largest known to me.

Locality and geological position.—This is a very rare species and is characteristic of the Productus-limestone. It has been found in this geological position by myself at Amb in the Chonetes bed (seven specimens), and by Mr. Wynne at the Verála scarp (one specimen) and in the Chittawán (one specimen).

Remarks.—I have no direct proof that this species really belongs to the genus *Spirigerella*, as all my endeavours to uncover the inside of it were in vain. From its whole configuration, however, and its general affinity to the species previously described, it appears probable that this species also belongs to the same genus.

The forms which are most nearly related to the present species are *Spirigerella derbyi*, W., and *Spirigerella minuta*, W. From both these shells the one here under consideration can be distinguished by its flatter valves, broader outline, the very large apical angle, and the presence of a distinct false area, which terminates latterally in two rounded corners.

Of not Indian species none is known to me which could be particularly compared to the present one.

10. SPIRIGERELLA ALATA, Waagen: n. gen. et sp., Pl. XXXVIII, figs. 7, 8.

The general form of this shell is elongately oval, considerably longer than it is broad. The valves are not much inflated, the ventral one with a distinct false area, which terminates in rounded corners on both sides. The species remains always rather small.

The ventral valve is very little arched, nearly quite flat. Longitudinally as well as transversely its curve is equally inconsiderable. The median sinus is very little developed, sometimes slightly, sometimes not at all impressed. The frontal part of the valve is somewhat produced and bent up, causing the frontal line to ascend in a broad arch. The beak is small, not very prominent, and well bent over, but never so much as to conceal its foramen entirely. The latter is small and oval if the beak is perfect, and appears larger if the beak is injured. On both sides of the beak there extends a broad, distinct, false area, marked off from the remainder of the shell by an obtuse not very distinct ridge and limited below by the but little curved hinge-line.

The dorsal valve is more strongly vaulted than the ventral one. The curve is not very strong in the longitudinal direction, but in the transverse direction it is more divided and somewhat parabolical. There extends a rounded crest from the apex of the valve to the frontal part, where it unites with the median fold, which is, however, barely indicated. The apex of the valve is pointed and strongly bent over, partly concealed below the apex of the larger valve.

The surface of the shell is more smooth than in other species of the genus. The distant imbricating striæ of growth are present in some specimens, but they are less strongly marked than is generally the case in the genus.

The internal characters of this species are entirely unknown to me.

The measurements of two specimens from Káfirkot are as follow:—

	I.	II.
Entire length of shell	16 mm.	14 mm.
Length of the smaller valve	15 „	13 „
Entire breadth of the shell	13 „	12 „
Thickness of both valves	9 „	8 „
Apical angle of the larger valve	106°	110°
„ „ „ smaller valve	116°	134°

The specimen No. I is the largest known to me.

Locality and geological position.—The species has been found up to the present only in one locality, at Káfirkot, west of the Indus. It was detected there by myself in a reddish distinctly oolitic rock, just at the limit between the middle and upper divisions of the Productus-limestone. A thin bed was filled with hundreds of individuals, none of which was larger than the specimen of which the measurements are given above. It was, however, not easy to extract the specimens from the rock. I brought away about a dozen.

Remarks.—This species is most nearly related to *Spirigerella numismalis*, W., described previously, and there is but little doubt that the two are in a developmental connection as they occur also in successive strata. The present species can be distinguished from the other by its smaller size and constantly more elongated form, and by a still less developed median fold.

Of non-Indian species none is known to me which could be compared particularly to the present one.

Genus :ATHYRIS, M'Coy.

From the excellent descriptions by Davidson, Derby, Zugmayer, &c, this genus has become one of the best known among all the genera of the spiral-bearing Brachiopoda. There remains nothing to be added as regards the internal structure, and as my materials are in many respects by far inferior to those that have been operated upon by those authors, I shall not attempt to describe again from my materials the features which have been already made out so admirably by others, and which I could observe only rather imperfectly. Only to some points I should like to draw attention, to the hinge-plate in the dorsal, and the hinge apparatus in the ventral valve.

The hinge-plate is a very characteristic feature of the present genus, and serves very well for the easy distinction of it and the preceding genus. It consists of a triangular plate occupying the space between the dental sockets, and spreading out horizontally for a more or less great extent between them. At both sides it is limited by ridges, which originate near the apex of the valve and are flattened on top. They form the commencement of the crura, which are the continuation of these ridges. The extremity of the apex of the valve is not complete, but is a little excavated for the passage of a visceral foramen which pierces partly the hinge-

plate and partly the apex of the valve. There is never so large a process developed as is characteristic of the preceding genus.

The hinge apparatus of the ventral valve is rather variable. The typical development is to be found in *Athyris royssii* and allied species. It consists of two large bifid hinge-teeth, which are sunk into the dental sockets of the dorsal valve in such a manner that it is impossible to separate the two valves without breaking either the dorsal valve or one of the hinge-teeth. The latter are supported by strong dental plates which are not united laterally with the outer wall of the shell, but are free near the apex of the beak. Below, near the bottom of the valve, they bend inwards and approach each other closely, almost uniting in the middle line. Thus a semicircular smooth space is marked off which extends from the end of the dental plates up to the margin of the foramen. The latter is not complete, but open at its lower end, and here shut in only by the apex of the smaller valve; a deltidium I have never observed.

The variation of the apparatus which I have mentioned above consists in the foramen being sometimes large, sometimes small, and the dental plates being sometimes entirely united with the outer walls of the shell, the space between them and the outer shell substance being filled up by shelly matter.

The forms which can be subsumed under this genus are rather numerous. According to Davidson's table the genus extends from the middle silurian to the triassic formation. The species which occur in upper palæozoic strata, and which are of chief interest to us, can be grouped within two large sections, one containing the forms with a smooth surface, the other with an ornamented shell surface; for the first I shall introduce the name "SIMPLICES," for the second that of "ORNATÆ." The first is much less numerous than the second. It contains in Europe the species *Ath. ambigua*, Phill., *Ath. globularis*, Phill., and perhaps *Ath. subtilita* (Hall?) Dav.; to these can be added *Ath. protea*, Abich, from permian and *Ath. epigona*, Abich, from carboniferous beds of the Persian frontier. These species can be subject again to a closer grouping, and then a very natural group is formed by the species *Ath. ambigua*, Phill., and *Ath. protea*, Abich, to which may be added one Indian shell which will bear the name of *Ath. ambiguæformis*, W. Another Indian species belonging to the section, but which cannot be brought into the same group as any of the European or Asiatic shells, must be considered as an isolated form. It will bear the name of *Ath. grossula*, W.

The second section is far more rich in species in Europe as well as in India. Among the European forms three groups can be distinguished: (1) group of *Ath. planosulcata*, Phill., comprising the typical species, and *Ath. expansa*, Phill.; (2), group of *Ath. royssii*, Lév., composed of the typical species, and *Ath. squamigera*, Kon.; and (3), group of *Ath. lamellosa*, Lév., with this single species.

In India only the second group is represented, but this by quite a number of species. I can distinguish *Athyris royssii*, Lév.; *Ath. subexpansa*, W.; *Ath. capillata*, W.; n. sp.; *Ath. globulina*, W.; *Ath. semiconcava*, W.; *Ath. acutomarginalis*, W.; and *Ath. pectinifera*, Sow.

According to these indications the Salt-range species can be grouped in the following manner:—

1.—Section Simplices.

I.—Group of Athyris ambigua, Phill.

1.—*Athyris ambiguæformis*, W.

II.—Group unknown.

2.—*Athyris grossula*, W.

2.—Section Ornatæ.

III.—Group of Athyris royssii, Lév.

3.—*Athyris royssii*, Lév.
4.— „ *subexpansa*, W.
5.— „ *capillata*, W.
6.— „ *semiconcava*, W.
7.— „ *acutomarginalis*, W.
8.— „ *globulina*, W.
9.— „ *cf. pectinifera*, Sow.

The geological distribution of these species is very irregular, some of them being restricted to a single bed, others ranging through the whole Productus-limestone.

Restricted to the upper Productus-limestone are *Ath. ambiguæformis*, *Ath. grossula* and *Ath. cf. pectinifera*, Sow.; characteristic of the lower Productus-limestone are *Ath. semiconcava* and *Ath. acutomarginalis*. *Athyris subexpansa*, W., ranges through the whole thickness of the Productus-limestone, whilst *Ath. royssii* and *Ath. capillata* are disseminated through the middle and upper divisions. *Ath. globulina* lastly has its chief distribution in the lower division, but extends also into the middle division.

Of all these species only two occur also in Europe: *Ath. royssii*, Lév., and *Ath. cf. pectinifera*, Sow. The first of these is a species that is common to the carboniferous and permian formations; the second has been indicated as of only permian age, but seems to occur in sporadic specimens also in the upper carboniferous limestone.

I. Section: SIMPLICES.

I.—Group of *ATHYRIS AMBIGUA*, Phill.

1. Athyris ambiguæformis, Waagen: n. sp., Pl. XXXVIII, fig. 11.

The general outline of this species is broadly oval, little longer than broad, the greatest breadth being situated at the rather long and tolerably straight hinge-line. The valves are rather flat, little inflated, the front line nearly straight. The species always remains small.

The ventral valve is flat, sometimes with a median impression, which extends from near the beak to the frontal line, sometimes not. The beak is thus well bent

over and cut out at its apex with a small incomplete foramen. A false area is almost entirely wanting.

The dorsal valve is very little more strongly curved than the ventral one, and but very little of its apex is concealed below the beak of the opposite valve. There is no median fold developed.

The surface of the shell is almost entirely smooth, and the strong imbricating striæ of growth so conspicuous on all the species of *Spirigerella* are absent; only very fine concentric striæ of growth and sometimes a trace of concentric wrinkles can be observed. One of the specimens shows a slight trace, as if the margins of the valves had been expanded.

The interior structure of the species is not known to me.

The measurements of two specimens, No. I from Jabi and No. II from Kufri, are as follow:—

	I.	II.
Entire length of the shell	12·5 mm.	11 mm.
Length of the smaller valve	11·5 „	10 „
Entire breadth of the shell	12 „	11 „
Thickness of both valves	6 „	6·5 „
Apical angle of the larger valve	110°	100°
„ „ „ smaller valve	120°	115°

Locality and geological position.—The species is entirely restricted to the upper division of the Productus-limestone, and has been collected by me in this geological position at Jabi in the Cephalopoda bed (one specimen), and at Kufri (three specimens). By Mr. Wynne it has been found at Khund Ghát (four specimens).

Remarks.—I have placed this species in the group of *Athyris ambigua* on account of the longitudinal impression exhibited by some specimens, and which also in young specimens of Phillips' species is sometimes present, sometimes not. Otherwise, however, there exists no great affinity between the two species, and they can easily be distinguished by the much smaller beak, the compressed valves and the nearly straight hinge-line of the Indian shell.

Another form which bears a certain resemblance to *Ath. ambiguæformis* is *Spirigera janiceps* var. *bipartita*, Stache, from the Bellerophon-limestone of the Alps; the resemblance is, however, only a distant one.

II.—Group unknown.

2. Athyris grossula, Waagen: n. sp., Pl. XXXVIII, figs. 9, 10.

The general outline of this species is rather variable, sometimes more elongated, sometimes nearly globular; it is, however, always characterised by a more or less distinctly produced frontal part. The valves are inflated, the beak small, and the front line nearly straight.

The ventral valve is strongly inflated with a very regular curve in the longitudinal as well as in the transverse direction. The frontal part is strongly produced, but very little or not at all bent up. The beak is very thin, not prominent, and well bent

over, bearing at its apex a small, fine, complete foramen. Below it there is a large triangular space cut out, which is not entirely filled up by the apex of the smaller valve. No distinct false area is developed.

The dorsal valve is slightly more strongly vaulted than the ventral one, tolerably equal in its curve in both directions, only the apex is strongly bent in being much concealed below the apex of the large valve. The frontal part is distinctly produced, but a median fold is not developed.

The surface of the shell is covered by numerous concentric striæ of growth which from distance to distance are more strongly marked. A very fine radial striation can also be seen.

Of the internal characters of this species nothing is known to me.

The measurements of two specimens from Chidru are as follow:—

	I.	II.
Entire length of the shell	15 mm.	17 mm.
Length of the dorsal valve	14·5 „	16 „
Entire breadth of the shell	14·5 „	14 „
Thickness of both valves	10·5 „	10 „
Apical angle of the larger valve	105°	95°
„ „ „ smaller valve	108°	101°

Locality and geological position.—This species is restricted to the upper division of the Productus-limestone, but is on the whole very rare. It has been collected by myself at Chidru (five specimens) and at Jabi, both in the Cephalopoda bed.

Remarks.—The produced frontal part of this species is a character which makes the distinction from other forms easy. It resembles thereby certain varieties of *Ath. lamellosa*, but is otherwise very distinct from that species. Of lamellar expansions there is nothing observable on any of my specimens.

II.—Section: ORNATÆ.

III.—Group of *ATHYRIS ROYSSII*, Lév.

3. Athyris royssii, Léveillé: Pl. XL, figs. 6-12.; Pl. XXXIX, fig. 10.

1835. *Spirifer de roissyi*, Léveillé: Mem. Soc. Géol. de France, Vol. II, p. 39, Pl. II, figs. 18—20.
1842. *Terebratula royssii* (Lév.), Koninck: Anim. foss., du Ter. Carbonif., p. 300, Pl. XXI, fig. 1.
1858. *Athyris royssii* (Lév.), Davidson: Monogr. Brit. Carbonif. Brachiop., p. 84, Pl. XVIII, figs. 1—11.
1862. *Athyris royssii* (Lév.), Davidson: Quar. Journ. Geol. Soc., London, Vol. XVIII, p. 27, Pl. I, fig. 6.
1863. *Athyris royssii* (Lév.), Davidson, Koninck: Foss. paléoz. de l'Inde, p. 33, Pl. IX, fig. 6.

This species has been excellently described already by quite a number of observers, and I need here only give some remarks about the Indian specimens.

The general outline of these shells is generally transversely oval, sometimes slightly pentagonal, with more or less inflated valves. Two points are very variable in the general configuration of this shell; these are the development of the median fold with the corresponding bend of the frontal line, and the size of the apical foramen.

The ventral valve is generally very equally convex in both directions, and provided with a more or less deep sinus in the frontal region which never reaches further up than half the length of the valve. The frontal part of the valve is always slightly produced, so that the frontal line is curved upwards, even when there is no sinus. The beak is tolerably thick but not much promiment, only so far bent over that the foramen opens just in the plane of the dorsal valve. The foramen is sometimes very large, sometimes smaller, but never very small. It is drawn much too small in figs. 8 and 9 of Pl. XL. A distinct false area is never present.

The dorsal valve is about equally strongly vaulted as the ventral one. Its most remarkable feature is the median fold, which is in general not very strongly developed and always restricted to the frontal region. Nevertheless the front-line is always more or less strongly curved, and in some exceptional cases this is so strong that it bends up and down as in some specimens of *Martinia glabra*, Mart. Such cases are, however, very rare; there is but one specimen in the Salt-range collection which shows this strong curve of the front-line. The front-line is, however, always curved, though sometimes only slightly, even in quite young specimens.

The surface of the shell is covered by very numerous concentric lamellar striæ of growth, of which some are more strongly marked. The fringes with which these shelly lamellæ were ornamented are only very rarely preserved, but as far as they can be seen they are exactly like those of the European specimens.

The internal arrangement of the species I could only observe badly and with difficulty; but as far as I was able to make it out, it seemed to agree exactly with the corresponding parts of European specimens. Only the internal side of the ventral valve and the cardinal part of the dorsal one am I able to describe more closely.

In the ventral valve the cardinal teeth are very strongly developed and bifid, consisting of a less elevated external and a very high internal part, which fits into a deep groove within the sockets of the dorsal valve. The cardinal teeth are supported by strong dental plates. The muscular impressions are very distinctly visible. The adductors are situated within a bifid, somewhat cordiform, deep impression in the middle; they are not very large. So much the larger are the divaricators; they encircle the others on both sides and extend yet a good distance below them, approaching each other very closely, or separated from each other by a broader shelly zone. The remaining portion of the shell is generally distinctly radially striated.

The cardinal part of the dorsal valve has been described already in the diagnosis of the genus, and the specific variations of the type are very small. In large specimens of this species the median part of the hinge-plate is very much thickened, the visceral foramen in it becomes slit-like, but pierces the hinge-plate entirely at the apex as in smaller specimens. On the upper side of the median part of the hinge-plate there is an eccentric open canal, which extends from the visceral foramen to the lower margin of the hinge-plate. The muscular impressions of this valve could not be observed, as the only specimen which could be exposed on the inside was but fragmentary.

The measurements of two specimens, No. I from Khairabád and No. II from Kálabágh, are as follow:—

	I.	II.
Entire length of the shell	39 mm.	28 mm.
Length of the smaller valve	37 „	26 „
Entire breadth of the shell	46 „	32 „
Thickness of both valves	29 „	17 „
Apical angle of the ventral valve	125°	120°
„ „ „ dorsal valve	130°	133°

No. I is the largest specimen that has been observed by me, but it is a partial internal cast.

No. II represents the average size of the specimens occurring in the Salt-range.

Locality and geological position.—The present species is not at all rare in the Salt-range, and is there chiefly represented in the middle and upper divisions of the Productus-limestone. In the lower division its occurrence is not beyond doubt. There are three specimens from Pail, collected there by me in the upper beds of the lower division, which I can directly unite with this species, but the specimens collected in the lowest beds I can only quote as *Ath. cf. royssii.*

In the middle division the species has been collected by myself in the mountains east of Katwáhi (ten specimens), at Katta (two specimens), on the road between Vurcha and Ucháli (five specimens), and at Musakheyl (ten specimens). Mr. Wynne has found the species at Morah (eight specimens), at Khund (two specimens) and Trans-Indus at Kálabágh (six specimens), in the Paránga Kass (one specimen), and north of Káfirkot (two specimens).

In the upper division it has been found by myself at Chidru (eight specimens), west of Khura (12 specimens), and in the Cephalopoda bed at Jabi (one specimen).

In connection with these indications it must always be borne in mind that the determination of quite young specimens remains always somewhat doubtful, and that the numerical indications can only be considered so far exact as *to the best of my belief* the specimens belonged to this species.

Remarks.—I consider as belonging to this species only the typical forms which occur in Europe in the mountain-limestone, while the smaller forms without an indication of a sinus in the large valve I shall quote under the heading *Ath. pectinifera.* I cannot enter here upon the question whether in Europe the two species can be distinguished; in India I can distinguish easily two forms, one with a sinus even in young specimens and one without it. The difference between the two is very striking, and the specimens of one form can easily be picked out from among the specimens of the other.

The specimens which I have described under the name of *Athyris royssii* seem to me to agree in every respect with the typical form of the mountain-limestone, and I am perfectly in accordance with Mr. Davidson, who described a large specimen of this species, from Musakheyl, under the above name.

Athyris royssii seems, however, in Europe not entirely to be restricted to the

mountain-limestone, but seems to pass up in its typical shape into the permian formation. The specimens figured by Golowkinsky under the name of *Spirigera concentrica* from permian beds at the mouth of the Janasaska river near Burtasy on the Volga seem undoubtedly to belong to this species; the muscular impressions of the ventral valve are absolutely identical with what I have described above in Indian specimens.

4. Athyris *cf.* royssii, Lév.: Pl. XLI, figs. 9, 10.

There is a number of specimens in the Salt-range collection, which all come from the lower division of the Productus-limestone, and which, though in general similar to *Athyris royssii*, yet cannot directly be identified with that species on account of the constant absence of the outer layer of the shell, and with this of the characteristic fringes of *Athyris royssii*. I therefore prefer to quote these shells under a separate heading.

Locality and geological position.—This form is never common, and always occurs only in the coaly or gritty sandstones at the base of the Productus-limestone. The greatest number of specimens (six) was found by me in the Chonetes bed at Amb. Another specimen was collected by Mr. Wynne at Dokri; and one specimen comes from the Trans-Indus continuation of the Salt-range, but the exact locality of it is unknown; it was contained in Dr. Verchere's collection, and is also preserved in a black coaly sandstone.

5. Athyris subexpansa, Waagen: n. sp., Pl. XXXIX, figs. 1—5.

The general outline of this species is very transversely oval; the valves are rather flat. In the ventral valve a distinct sinus is always present. The ornamentation of the shell is similar to that of *Athyris royssii*.

The ventral valve is not much inflated, somewhat more strongly curved in the longitudinal than in the transverse direction. The middle portion of the frontal part is slightly produced. A distinct sinus is present, which extends nearly over the whole length of the valve and becomes more and more distinct and deeply impressed as the specimens grow larger. The front line is more distinctly bent up in the middle in large than in small specimens. This part is, however, rather narrow in comparison to the transverse diameter of the shell. The beak is thick, not very prominent, and little bent over, truncated at its apex by a large round foramen, which is not complete below. A false area is not developed.

The dorsal valve is identical in its curve with the ventral one. It bears no median fold, and is slightly cut out in the middle of the frontal region. Only a very small part of the apex is concealed below the beak of the opposite valve.

The ornamentation of the shell consists of very numerous concentric striæ of growth, of which some are more strongly marked. Each of them bears a shelly lamella which is thickly set at its margin with shelly fringes the length of which

could not be observed. The shelly lamella to which the fringes adhere is more strongly developed in this species than in *Ath. royssii.*

The internal arrangement of this species is not known to me.

The measurements of two specimens, No. I from Khura and No. II from Musakheyl, are as follow:—

	I.	II.
Entire length of the shell	31 mm.	25 mm.
Length of the smaller valve	29 „	23·5 „
Entire length of the shell	43 „	34 „
Thickness of both valves	18 „	15 „
Apical angle of the larger valve	130°	135°
„ „ „ smaller valve	141°	146°

No. I is the largest specimen known to me.

Locality and geological position.—The species begins to appear in the lowest beds of the middle division of the Productus-limestone, perhaps even in the lower division (Chilámi, Trans-Indus, three specimens), and extends up into the upper division, being most numerous in the upper beds of the middle division.

It has been collected in the middle division by Dr. Oldham at Swás (seventeen specimens), by myself at Nursing Pohár, lowest beds of compact limestone (two specimens), at Virgal in the Crinoid beds (two specimens), by Drs. Oldham and Warth at Musukheyl (six specimens), and by Mr. Wynne at Kálabágh (eight specimens).

In the upper division it has been found by myself in the section at Khura (12 specimens), at Jabi in the Cephalopoda bed (five specimens), and at Nanga (one specimen), and by Mr. Wynne, Trans-Indus, north of Káfirkot (one specimen).

In the very top beds of the Productus-limestone one specimen was collected by myself at Amb.

Remarks.—This species in its general configuration seems to be most nearly related to *Athyris expansa*, Phill. It can, however, be distinguished from that species by a well-developed sinus in the ventral valve and by its fringed expansions. By the latter it seems to be more or less nearly related to *Athyris royssii*, and chiefly to that form which has received from Count Keyserling the name *Athyris royssiana*. Keyserling adduces as chiefly characteristic of his species the large apical angle (above 130°). This, it is true, is also a character of the present species, but the Russian permian shell has at the same time compressed spread-out margins, and generally also a less large transverse diameter, so that I did not consider it advisable to unite the Indian with the Russian forms. Perhaps both are geographical varieties or vicarious species.

6. Athyris capillata, Waagen: n. sp., Pl. XXXIX., figs. 6-9; Pl. XL., figs. 1-5; Pl. XLII., figs. -15.

1867. *Athyris sp.*, probably *A. Royssii* (Lév.), Verchere: Kashmir, the Western Himalaya, and the Afghan Mountains: Journ. As. Soc., Beng., Vol. XXXVI, p. 211, Pl. II., figs. 3, 3a.

This species has a transversely oval or nearly globular outline, more or less strongly inflated valves, which are thick and heavy, and covered by extremely

numerous lamellar striæ of growth. The latter are strewn all along with thickly set hair-like fringes. The species attains no very considerable dimensions.

The ventral valve is from moderately to very strongly inflated, and in both directions about equally curved. It bears always a distinct sinus, which reaches up about half-way the length of the shell. In the frontal region the valve is but little produced. The beak is thin, not prominent, well bent over, and pierced at its apex by a very small incomplete foramen. No false area is developed.

The dorsal valve is equally inflated as the ventral one and of a very regular curve in both directions. Only very little of the apex is concealed below the apex of the larger valve. There is always a median fold, but not very strongly marked off from the remainder of the shell. Sometimes this fold bears on its top a longitudinal impression.

The sculpturing of the shell is very characteristic. It is covered all over by extremely thin and numerous lamellar striæ of growth, of which I count four to six within the space of one millimetre. The margins of these lamellæ are again very closely set by hair-like shelly fringes, which are, however, on account of their extreme fineness, only rarely preserved, and the full length of which I was not able to observe. The enlarged fig. 46, Pl. XLII, gives a good idea of the fineness of these fringes.

The internal arrangment of this species has been fairly well made out. The arrangement of the spirals and loop is very similar to that occurring in *Ath. ambigua*, &c. The muscular impressions are characteristic in both valves. They could be studied in empty valves as well as on an artificial internal cast that I had prepared.

The ventral valve is thick and heavy, and the dental plates are united to the outer wall of the shell by a thick shelly callosity instead of being free as in *Ath. royssii*. The hinge-teeth are very prominent, hook-shaped and bifid. A deltidium is not present. The impressions of the adductors are very deep and strongly marked but very small. They begin in about the same line with the teeth and terminate about in the middle of the length of the shell at a more or less high septum, which originates here and extends to not far from the frontal margin of the valve. All the marginal part of the valve shows a reticulated grooving, which is again surrounded by a narrow smooth zone.

The dorsal valve bears a well-developed hinge-plate, which is flatly spread out and laminar in little inflated specimens, and thickly swollen in its middle part in strongly inflated individuals. It is pierced at the apex by a thin visceral canal terminating in a small foramen, which makes an incision at the apex of the valve. The crura begin at this foramen as shelly ridges fixed to the hinge-plate and limited on the outer side by high shelly crests, which form the inner walls of the dental sockets. The muscular impressions are distinctly visible chiefly on artificial casts. They are situated along the middle line of the valve, which is slightly raised in its upper region and excavated further down. One pair is situated above the other as in other species of *Athyris*. The upper pair is much smaller than the lower, which is at its upper termination enclosed between the former. Also in this valve the

greater part of the inner surface is occupied by a reticulated grooving, which is encircled immediately at the margin by a smooth zone.

The dimensions of two specimens, one of the thicker, the other of the thinner variety, both from the Cephalopod bed of Jabi, are as follow :—

	I.	II.
Entire length of the shell	24·5 mm.	24 mm.
Length of the smaller valve	23·5 „	22.5 „
Entire breadth of the shell	28 „	26 „
Thickness of both valves	16 „	19 „
Apical angle of the large valve	110°	106°
„ „ „ smaller valve	119°	115°

The specimens of which the measurements are given here are the largest known to me.

Locality and geological position.—The species begins in the middle division of the Productus-limestone, but is chiefly numerous in the upper division. In the latter position the species has been collected by myself at Jabi in the Cephalopoda bed (seventy specimens), at Chidru also in the Cephalopoda bed (twenty-six specimens), and in the section at Khura (four specimens). Mr. Wynne brought the species from Khund Ghát (thirty-four specimens) and from Bilot (one specimen).

At the limit between the middle and upper divisions the species has been found by myself in the section at Khura (four specimens) and at Káfirkot (seventy-six specimens), by Mr. Wynne at Khund (four specimens) and at Kálabágh (three specimens), and by Dr. Oldman at Musakheyl (four specimens).

In the middle region of the middle division I collected the species between Vurcha and Ucháli (thirty specimens), and at Chidru (eight specimens). Dr. Oldham and Mr. Wynne brought the species from Swás (nine specimens), and the latter collected it also in the Bazarwán (one specimen), at the Verála scarp (two specimens) and north of Káfirkot (two specimens).

From this list it appears that the present species is very common.

Remarks.—The species here under consideration is rather nearly related to the true *Athyris royssii*, but can be easily distinguished from that species by its more strongly developed sinus and fold at a comparatively small size, by its extremely numerous lamellar striæ of growth, and by the much finer hair-like fringes which are fixed to them.

Of other species none is nearly related or need be compared more particularly to the present one.

7. Athyris semiconcava, Waagen: n. sp., Pl. XLI, figs. 4—6.

The general outline of this species is more or less transversely oval, with a flat or even excavated ventral and a more or less strongly inflated dorsal valve. The frontal line is very strongly bent up, and the whole shell covered with hair-like fringes.

The flatness or excavation of the ventral valve is only developed in later stages of growth; young specimens up to a longitudinal diameter of about 10 to 15 mm. have a vaulted ventral valve, though its curve is never strong. The sinus is very strong, but very narrow, and reaches up for about half the length of the valve. The beak is very small, barely prominent, but little bent over, and pierced at its apex by a small incomplete foramen. There is not a trace of a false area.

The dorsal valve is rather strongly vaulted and its curve is about equal in the longitudinal and in the transverse direction. The longitudinal curve is strongest in the apical region. The median fold is very indistinct and only somewhat more strongly marked immediately at the front. This valve is slightly cut out in the frontal region for the reception of the prominent and bent-up shelly part of the other valve forming the sinus.

The ornamentation of the shell is very similar to that of the preceding species. The whole surface is covered by very closely arranged lamellar striæ of growth, each of which bears innumerable hair-like shelly appendages.

The interior characters of this species are unknown to me.

The measurements of two specimens from Amb are as follow:—

	I.	II.
Entire length of the shell	21 mm.	23·5 mm.
Length of the smaller valve	20 „	22 „
Entire breadth of the shell	30 „	27 „
Thickness of both valves	13 „	12 „
Apical angle of the larger valve	123°	121°
„ „ „ smaller valve	130°	124°

The species seems not to grow large, as no larger specimens have been detected up to the present.

Locality and geological position.—This is a very rare species and entirely restricted to the lower division of the Productus-limestone. It has been collected by myself at Amb in the Chonetes bed (seventeen specimens), and by Mr. Wynne at Dokri (three specimens).

Remarks.—The present species is easily distinguishable from other allied forms by its flat or excavated ventral valve. The only species which shows a certain similarity is *Athyris royssiana*, Keys. Though in that species the apical angle is similarly large, yet it can be distinguished by the circumstance that both valves are flat and thus form a broad compressed margin.

8. Athyris acutomarginalis, Waagen: n. sp., Pl. XXXVIII, figs. 12, 13.

I was for a long time in doubt whether I should not unite this species with *Athyris royssiana*, Keys., but as after a careful study and comparison I could only recognise a similarity in the two shells, but not an absolute identity, I preferred to describe the Indian form under a separate name.

The general form of this shell is transversely oval, but only slightly broader than long. The valves are curved, but the margins compressed. The apical angle

is not very large. The whole surface is covered by not very fine fringes. The species seems to remain small.

The ventral valve is distinctly, but not very strongly, vaulted, and somewhat flatly spread out along its margins. The middle of the frontal part is strongly produced. A narrow sinus is developed only in the frontal region. The beak is tolerably thick, prominent, not much bent over and pierced at its apex by a comparatively large incomplete foramen. No false area is developed.

The dorsal valve is about equally curved as the ventral one. The margins are flattened as in the other valve. In a longitudinal direction the curve is equal from the apex to the beginning of the median fold, when the shell is suddenly deflected. The median fold is narrow, but very prominent; it is, however, limited entirely to the frontal region.

The surface is covered with not very numerous but strongly prominent lamellar striæ of growth, of which some are more strongly marked. These lamellæ terminate in long hair-like fringes, which are, however, not so fine as those of *Athyris capillata*, but resemble more closely those of *Athyris royssii*.

The internal characters of this species are not known to me.

The measurements of two specimens from Amb are as follow:—

	I.	II.
Entire length of the shell	17 mm.	15 mm.
Length of the smaller valve	16 „	14 „
Entire breadth of the shell	19 „	18 „
Thickness of both valves	9·5 „	9·5 „
Apical angle of the larger valve	103°	109°
„ „ „ smaller valve	130°	124°

No larger specimens are known to me.

Locality and geological position.—This is a very rare species and has been found only at one locality in somewhat greater numbers. It is entirely limited to the lower division of the Productus-limestone. It has been collected by me at Amb in a black coaly sandstone below the Chonetes bed together with great numbers of a species of *Aulosteges;* fourteen specimens were brought away by me. One specimen was also found by me at Khura at the upper limit of the lower division of the Productus- limestone in yellow marly beds.

Remarks.—As I have remarked already above, there exists a very close relation between the present species and *Athyris royssiana*, Keys.; but it does not amount to identity. The general outline of the present species is much less transverse, the beak much thicker, and the apical angle by far smaller. Only the curvature of the valves is extremely similar in both shells.

Ath. royssii is distinct by a different curvature of its valves.

Keyserling's species, *Athyris royssiana*, seems to commence in sporadic specimens already in the upper carboniferous limestone of Russia and of Timor, but has its chief development only in the permian formation of Russia. In the mountain-limestone proper of England and Belgium it seems to be entirely absent.

9. ATHYRIS GLOBULINA, Waagen: n. sp., Pl. XLI, figs. 1—3.

The general outline of this species is entirely globular with very strongly inflated valves and a nearly straight frontal line.

The ventral valve is very strongly inflated, with an equal curve in both directions. The frontal part is slightly produced and bent up, so as to cause the front line to ascend a little, but a sinus is not developed. The beak is tolerably thick but not prominent, strongly bent over and firmly appressed to the apex of the smaller valve. It is pierced at its apex by a not very large semicircular foramen, the lower side of which is open and only closed by the apex of the smaller valve. A rather distinct but narrow false area extends on both sides of the beak.

The dorsal valve is equally strongly vaulted as the ventral one. Its apex is concealed to some extent below the beak of the opposite valve. Not a trace of a median fold is developed, though the front-line bends up a little.

The surface of the shell is covered by very neat and numerous concentric striæ of growth, which are distinctly crenulated on top, by which crenulation the appearance of a very fine radial striation is produced. Towards the margins of the valves the striæ of growth become somewhat more irregular and imbricating, when some of them are very strongly marked. This is the case chiefly in larger specimens. If the surface is entirely well preserved, the crenulated striæ of growth are provided with fringes as in *Ath. royssii*.

The internal characters of this species are not known to me.

The measurements of two specimens, No. I from North Káfirkot, No. II from Narsing Pohár, are as follow:—

	I.	II.
Entire length of the shell	18 mm.	14·5 mm.
Length of the smaller valve	16 „	14 „
Entire breadth of the shell	17·5 „	15 „
Thickness of both valves	15·5 „	12 „
Apical angle of the large valve	98° „	103° „
„ „ „ smaller valve	112° „	128° „

No larger specimens of this species have been observed by me.

Locality and geological position. This species is entirely restricted to the middle division of the Productus-limestone. It is, however, most numerous in the lowest beds of that division. By myself it has been collected at Katta in a yellowish grey limestone (four specimens) and at Narsing Pohár in a black coaly limestone (four specimens), at both localities in the very lowest beds of the middle division of the Productus-limestone. In somewhat higher beds the species has been collected by me at Khura (one specimen) in grey thin-bedded limestones. By Mr. Wynne the species has been found at Vurcha in the middle division (one specimen) and Trans-Indus north of Káfirkot (two specimens) in the same division.

Remarks.—The general configuration of this species is very characteristic, which is not repeated by any other species of *Athyris*. That the species belongs to the group of *Athyris royssii* is indicated by the fringes by which the concentric

striæ of growth are ornamented, but otherwise its affinity to that species is rather remote.

Of other species none need be more closely compared to the present one.

10. Athyris *cf.* pectinifera, Sowerby: Pl. XXXVIII, fig. 14.

1840. *Atrypa pectinifera*, Sowerby: Min. Conch., Vol. VII, p. 14, Pl. 616.
1845. *Terebratula pectinifera* (Sow. sp.), Verneuil: Paléontologie de la Russie, p. 57, Pl. VIII, fig. 12 *a*, *b*.
1850. *Cleiothyris pectinifera* (Sow. sp.), King: Mon. Brit. Perm. Foss., p. 138, Pl. X, figs. 1—10.
1858. *Athyris pectinifera* (Sow. sp.), Davidson: Brit. Perm. Brach., p. 21, Pl. I, figs. 50-56; Pl. II, figs. 1—5.
1861. *Athyris pectinifera* (Sow.), Geinitz: Dyas, Vol. I, p. 86, Pl. XV, figs. 49—50.

I cannot but consider the little shells, one of which is figured on the above plate, as distinct from other species of *Athyris*, though I am not so certain as to their belonging to Sowerby's species.

The general outline of the species is lenticular, about as long as it is broad, with a small beak and a straight front-line.

The ventral valve is moderately convex, not produced in the frontal region, and without a sinus. The beak is small, little prominent and barely at all bent over, pierced at its apex by a small semicircular foramen, which is incomplete below, and shut in only by the apex of the smaller valve. No false area is present.

The dorsal valve shows the same course as the ventral one and bears not a trace of a median fold.

The surface of the shell is characteristically ornamented. It shows a number of more or less distinctly developed undulating concentric folds and many lamellar striæ of growth, which are crenulated on top. The fringes, however, the existence of which is indicated by this crenulation, are not preserved on any of the specimens. The substance of the shell is very thin.

The internal arrangement is only partly known to me. The figured specimen shows the spirals in a somewhat weathered condition. Each of the coils consists of twelve circuits, which have a very flatly oval form, and become more and more compressed as they approach the margins of the shell, so that the last are nearly angular. The two coils approach each other about equally on the dorsal and on the ventral side. The cardinal part is covered up by rocky matter, and thus the accessory lamellæ as well as the loop cannot be seen.

The measurements of the figured specimen are as follow :—

Entire length of the shell	13 mm.
Length of the smaller valve	12·5 „
Entire breadth of the shell	12 „
Thickness of both valves	7 „
Apical angle of the larger valve	110°
„ „ „ smaller valve	125°

Locality and geological position.—The typical specimen was collected by me in the Cephalopoda bed at Jabi. Other specimens belonging also very likely to the species have been collected by myself at Chidru (three specimens), west of Khura

(two specimens) and near Katwáhi (one specimen), at all three localities in the upper division of the Productus-limestone. Mr. Wynne found the species in the middle division of the Productus-limestone at Swás (six specimens).

Remarks.—It is with great doubt that I identify this form with *Ath. pectinifera*, but my materials are not sufficient to make a new species of it. The shells here under consideration are similar to *Athyris pectinifera* by their general shape, the straight front-line and their constantly small size. They differ from it by their thin shell with concentric undulations, and by the very compressed spirals, which bear more circuits than those of *Athyris pectinifera*.

This is all that I can state, and in the expectation that somebody will find more complete materials I adduce these shells for the present in a provisional manner under the name of *Athyris cf. pectinifera*, Sow.

Family : *NUCLEOSPIRIDÆ*, Dav.

This family has a smaller extent than the other families of the *Spiriferacea*, but it is not less excellently characterised. The simplicity of its loop, which holds good in all the genera belonging to the family, is a character which can without very great difficulty be detected, and forms a link by which all the forms appear to be more or less closely connected. Nevertheless in this family also a certain number of types of development can be distinguished, a circumstance which has been indicated already by Davidson. These types are marked not so much by differences in the arrangement of the loop as by peculiarities in the primary lamellæ of the spirals. Whilst in the preceding family the primary lamellæ are attached to the crura always with a strong and sudden acutely angular bend, in this family there is only one group in which this bend is typically developed; in the other groups the attachment takes place in a different manner. This first group includes, according to Davidson's indications, four genera : *Nucleospira*, Hall ; *Retzia*, King ; *Meristina*, Hall ; and *Hindella*, Dav., to which with great probability may be added *Trematospira*, Hall. A genus which has not been mentioned by Davidson but which also belongs to the group is *Eumetria*, Hall. These genera together form a very natural group, which very conveniently may be considered as a sub-family, for which I shall introduce the name of " RETZIINÆ."

A second group as indicated by Davidson is formed by the genus *Dayia*, Dav. It is characterised by the circumstance that the crura are joined by the primary lamellæ at about right angles, and that these lamellæ then follow the margins of the shell, so that the spiral coils, which are very small and have very few whorls, are nearly enclosed between them. This group, though comprising up to the present not more than one genus, well deserves to be considered as forming a sub-family, which will have to bear the name of "DAYINÆ."

The third group which has been distinguished by Davidson includes also only one genus, the genus *Uncites*, Defr. In this genus there is no distinction between the crura and the primary lamellæ ; and in this respect the genus approaches most

nearly the true *Spirifera*. There is no doubt that also this genus deserves to be considered as forming a distinct sub-family under the name of "UNCITINÆ."

In the Salt-range the family *Nucleosrpiidæ* is not very numerously represented, yet the species occurring there can be distributed under two sub-families. The sub-family *Retziinæ* is represented only by the genus *Eumetria*, Hall, with two species. Another kind of shells that occur in the Salt-range represents a new genus, the systematic position of which is, however, not beyond all doubt, as the entire internal apparatus is not known to me. From all that can be ascertained this shell seems to bear a certain affinity to the genus *Uncites*, and therefore will receive by me the name of *Uncinella*, and will be placed in a provisional way in the sub-family *Uncitinæ*.

The geological distribution of the genera belonging to the family has been indicated already by Davidson. Only the distribution of *Retzia* as indicated by Davidson seems somewhat doubtful, as in the more recent formations the genus seems for a great part to be replaced by the genus *Eumetria*, Hall

The sub-family *Uncitinæ* seems not to be restricted to the devonian period; not only has Quenstedt already figured fossils from the mountain-limestone of Ratingen, which he calls *Uncites carbonarius*, and which though certainly not belonging to this genus yet very probably form part of the sub-family, but also in the Salt-range, in beds which are certainly more recent than the mountain-limestone, the genus *Uncinella* occurs, which I consider as belonging with great probability to the sub-family *Uncitinæ*.

Sub-family: *RETZIINÆ.*

Genus: EUMETRIA, Hall.

This genus has been very imperfectly known up to the present, and it is not without much doubt that I assign the Salt-range forms to Hall's genus.

The genus has never been properly described by Hall. The name was introduced in 1863, in the sixteenth Regent's Report of the New York State Cabinet p. 59, for the shells of the type of *Retzia serpentina*, Kon.; but this species itself is of a very problematic nature as to its generic relations, and it is very doubtful if the figure in Woodward's Manual represents what was assigned by Koninck under the name. Dall has therefore very properly considered *Retzia vera*, Hall, as the type of the genus, which species somewhat earlier in the text (page 55) was figured by Hall as a representative of the *serpentina* type. If we take this species as the type we can then find out approximately what is denoted by the name.

I shall now first proceed to describe the characters of the genus from the Indian materials, and then only undertake a comparison with Hall's type.

The general form of the shells belonging to the genus is elongately oval, with a more or less quickly tapering beak which is truncated at its apex by a large round foramen. Below it there is a small but very distinct and sharply defined area, on which no trace of a deltidium is visible. The hinge-line is straight, and at both ends of it the ventral as well as the dorsal valve is produced into small wings. The shell

is radially plicated, and the front line is straight, without median fold or sinus, in all the species that are known to me.

The substance of the shell is punctate.

The internal characters of the shell are very peculiar. The ventral valve is very simple inside: from the straight hinge-line there project, not far distant from each other, two small hinge-teeth, which are otherwise in no way remarkable; they are not supported by dental plates, and are not continued inside the area as projecting ridges. The muscular impressions are so indistinct in all the specimens I have for observation, that I cannot say anything positive about them.

The dorsal valve has a very complicated brachial apparatus. The cardinal process consists of a transversely elongate squarish upright plate, which extends below the area of the larger valve, and between this plate and the apex of the dorsal valve the median part of the area is so firmly wedged in that it is impossible to separate the two valves without breaking off the middle part of the area which then remains sticking in its place and can only with great difficulty be removed. On both sides of this cardinal process are the dental sockets, which are very small for the reception of the small hinge-teeth. Anteriorly and somewhat above the dental sockets the crura take their origin. The cardinal process or hinge-plate, as one might like to call it, is produced below into a stout hooked process, which is again supported by a small semilunar septum, which latter, however, seems to be only rudimentary in some cases. The hooked process shows much similarity to the curved tube which encloses the visceral canal in some species of *Athyris*, and which terminates at the apex of the valve in the visceral foramen. The species of *Eumetria* which I have for investigation are, however, too small to make certain whether the hooked process described above is pierced by a canal or not. Also the apex is so much concealed by the prominent cardinal process, that one cannot be certain as to the existence or absence or a visceral foramen.

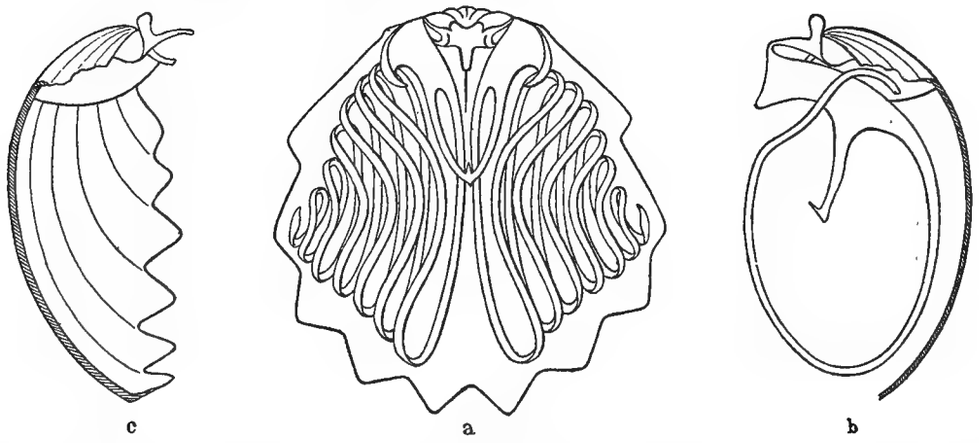


Fig. 7. EUMETRIA GRANDICOSTA (Dav.), Waagen: Specimen from the Cephalopoda bed of the upper Productus-limestone of Jabi: *a*, ventral view of the spirals and loop; *b*, lateral view of the loop and primary lamellæ; *c*, lateral view to show the shape of the septum, &c.;—all figures strongly enlarged.

The crura, as has been said above, take their origin on both sides of the cardinal process at the margin of the dental sockets. They are slender, not very long,

rather straight and extend in an obliquely ascending direction. They join the primary descending lamellæ of the spirals with a very acute bend. The primary lamellæ are very strange in their development. They show broad wing-like expansions at their origin which are sometimes very strongly developed as in the specimen figured in the woodcut, sometimes less so, but they are always present. Very near below the origin, from the broad part of the primary lamellæ, the loop proceeds. It consists of two slender nearly quite straight lamellæ which converge about in the direction of the longer axis of the valve towards the middle, and unite in forming a little sharply pointed spur which is directed obliquely towards the apical part of the valve. From the origin of the loop the primary lamellæ taper very quickly.

The spirals are very loosely coiled and consist of six to eight volutions. Whilst the primary lamellæ on the dorsal side approach each other very nearly, their recurving branches on the ventral side are rather distant from each other, so that the entire loop lies open to inspection.

The muscular impressions are not visible in this valve.

From this description it appears that the shells which I subsume under the name of *Eumetria* can be very well distinguished generically from other genera of the sub-family. The most striking features are the wing-like expansions of the primary lamellæ, the origin of the loop so near the commencement of the primary lamellæ, and its extension forward in a horizontal direction, just the opposite of what takes place in the genus *Hindella*. The genus *Eumetria* thus seems to be much more removed from the remainder of the genera of the *Retziinæ* than the genera *Nucleospira*, *Retzia* and *Meristina* are from each other.

If we now proceed to the comparison of the shells which have been here described with Hall's type of the genus *Eumetria*, we find that externally there exists a very great resemblance: Hall's type also has a small very sharply defined area, which shows no trace of a deltidium; the hinge-line is straight and produces wing-like expansions in both valves. So far the generic identity of the Indian shell with Hall's type cannot be doubted. It is more difficult to explain the cardinal section of *Eumetria vera* as figured by Hall. The lines which are visible on that section can, I think, be explained in the following manner: 'l' is the section of the hinge-plate, which ascends from the bottom of the cardinal part of the valve and forms the dental sockets; 's' is the lowest part of the cardinal process enclosed between the origin of the crura, and 'c' represents part of the crura and wing-like expansions of the primary lamellæ. This interpretation of the different parts seems to be sufficiently natural to allow in this respect of the generic identification of the Indian shells with Hall's type.

A somewhat more circumstantial description of the internal parts of the genus *Eumetria* is to be found in Derby's paper on the Brachiopoda of Itaituba, a paper which is full of most valuable information about the interior structure of these Molluscoids. Mr. Derby says: "In the interior of the ventral valve the teeth are small, unsupported by dental plates and situated near the extremity of the hinge-line. No septum has been observed, and the muscular marks are indistinct."

"In the dorsal valve the cardinal process forms a broad, transverse, curved plate, convex towards the front of the valve, and bent back past the hinge-line into the beak of the ventral valve. Anteriorly its margins are united with small socket plates, projecting straight forward and supporting the spires from their margins. From the middle of the lower part of the anterior face of the plate forming the cardinal process, a slender hooked process projects forward and upward, the inferior face of this process bearing a small thread-like ridge, which is continued along the bottom of the valve as a mesial septum, and on each side of which is an elongated oval muscular scar. Each spire consists of six (?) coils, the first of which has a small triangular spur near the origin at the point where the two spires most nearly approach each other; outer margin of coils pectinated."

In this description it is easy to recognise the internal arrangement of our Indian shells, though it is evident that it has been drawn up from very imperfect specimens, in which the crura were not preserved, so as to give the opinion that the spires were fixed to the socket-plates. How easily such a mistake might take place a glance at my woodcut will show. The spurs, which he describes as projecting from the primary lamellæ of the spires, are the rudiments of the loop, which was not entirely preserved, and the exact form of which he could therefore not ascertain. Otherwise Mr. Derby's observations are confirmed by my studies on Indian shells in the most remarkable manner.

It would then seem but little doubtful that the Indian shells belong really to the genus *Eumetria*, which is thus shown to extend also into Asian territory.

Much more difficult than to determine the geographical range of the genus is it to indicate its geological distribution. It seems to begin in the mountain-limestone proper and to extend up into the trias, but as the interiors of the triassic shells are very imperfectly known it is not possible to say anything positive.

In India there are only two species of the genus which both seem to stand in a rather close connection to two European species, *Retzia radialis*, Phill., and *Retzia ulotrix*, Kon. It is not known whether the European forms possess the internal characters of *Eumetria*, but the external shape, chiefly the small area without deltidium, makes it probable that this is the case. Mr. Davidson has already drawn attention to the similarity of one of the Indian species to *Retzia radialis*, Phill., and he found the affinity between the two forms so close that he considered the Indian shell only as a variety of Phillips' species. Mr. Kayser has, however, expressed the opinion that the Indian form represented a distinct species, and I cannot but concur with that learned author on this point.

The second species is more or less related to *Retzia ulotrix*, Kon. Also this species, judging at least from its external characters, is very probably an *Eumetria*.

It is highly probable that the Indian species are in a developmental connection with the respective European ones. We thus have—

I.—Group of EUMETRIA RADIALIS, Phill.

1. *Eumetria grandicosta* (Dav.), Waagen.

II.—Group of Eumetria ulotrix, Kon.

2. *Eumetria indica*, Waagen.

The geographical distribution of the two Indian species is not indentical. *Eumetria grandicosta* begins already in the lowest beds of the Productus-limestone and extends up through the middle into the upper division; *Eumetria indica*, on the contrary, is tolerably numerous only in the lowest beds of the middle division, and only isolated specimens are to be met with in lower or somewhat higher beds. It is entirely absent in the upper division of the Productus-limestone.

I.—Group of *EUMETRIA RADIALIS*, Phill.

1. Eumetria grandicosta (Dav.), Waagen: Pl. XXXIV, figs. 6—12.

1862. *Retzia radialis*, Phill., var. *grandicosta*, Davidson: Quart. Jour. Geol. Soc., Lond., Vol. XVIII, p. 28, Pl. I, fig. 5.

1863. *Retzia radialis*, Phill., var. *grandicosta* (Dav.), Koninck: Foss. paléoz. de l'Inde, p. 33, Pl. IX, fig. 5.

1882. *Retzia grandicosta* (Dav.), Kayser: Obercarbonische Fauna von Lo-ping; Richthofen's China, Vol. IV, p. 176.

The general outline of this species is more or less elongately oval, with a more or less slender prominent beak, and a small triangular area below it. Neither sinus nor median fold is developed. Both valves are covered by strong radiating costæ.

The ventral valve is moderately and evenly convex. The beak is long, quickly tapering and well bent over, always distant from the apical part of the dorsal valve. It is pierced and truncated at its apex by a large oval foramen. Below the foramen there extends a small triangular area, which does not occupy the entire interior or dorsal side of the beak, but is considerably narrower. The area forms a triangle of about equal sides, of which the base is formed by the straight hinge-line. The valve bears twelve to fourteen radiating costæ, which are rounded on their tops and are separated from each other by rounded furrows. Of these furrows the median one is sometimes, but not always, slightly broader and deeper, forming a kind of a very indistinct sinus, which, however, does not cause the front line to ascend.

The dorsal valve is equally vaulted as the ventral one. It is limited above by a short straight hinge-line, which causes small wing-like expansions of the valve to be formed on each side. The valve is covered by eleven to thirteen radiating costæ of the same character as those of the ventral valve. The median of these costæ is nearly always a little stronger than the others, but the difference in size is very small indeed.

The surface of both valves is nearly quite smooth, the striæ of growth being very indistinctly marked. The substance of the shell is generally so strongly silicified that the punctation is only rarely and then not very distinctly visible.

The internal characters are those given in the description of the genus.

The measurements of two specimens, the largest known to me, No. I from Jabi, No. II from Káfirkot, are as follow :—

	I.	II.
Entire length of the shell	14 mm.	14 mm.
Length of the smaller valve	12 „	12 „
Entire breadth of the shell	10 „	12·5 „
Thickness of the valves	9 „	9·5 „
Apical angle of the larger valve	63°	80°
„ „ „ smaller valve without the wings	100°	117°

No. I represents the typical form, while No. II is of an exceptionally broad variety.

Locality and geological position.—The species is nowhere very common, and is equally distributed through the whole thickness of the Productus-limestone; only in the topmost beds of the formation the species has not yet been found.

It has been collected by myself in the lower division at Amb in the so-called *Chonetes* bed (twenty specimens). In the middle division I found it myself on the road between Vurcha and Uchâli (one specimen), in the section at Khura in the highest beds of the division (two specimens), and Trans-Indus at Káfirkot (seven specimens). Mr. Wynne has brought the species from the Chittawán (one specimen) and from Budikheyl (one specimen), Mr. Warth from Musakheyl (five specimens). In the upper division I collected the species in the Cephalopoda bed at Jabi (six specimens).

Remarks.—The present form has been united by Davidson with *Retzia radialis*, Phill., and was considered by him as forming only a variety of that species which he designated as *var grandicosta*. It cannot be doubted that the shell here under consideration is very nearly related to Phillips' species, yet I think the differences are sufficient to distinguish specifically between the two forms. *Retzia radialis* appears to remain always smaller, is in its outline much broader in comparison to its length, and has in general flatter valves. By far the majority of specimens have much more numerous ribs and a by far more distinctly developed median sinus and fold. The chief difference, however, seems to consist in the differently developed beak, which is barely bent over and pierced by a comparatively small foramen, and which bears on its dorsal side an area comparatively much larger than that of *Eumetria grandicosta*. These latter differences are very constant and make a distinction in every case not very difficult.

Much more nearly related to the present species than *Retzia radialis*, Phill., seems to be *Eumetria mormonii*, Marcou. The only difference in this case consists in slightly more numerous ribs and a distinct sinus, occupied by two folds, in the ventral valve in *Eumetria mormonii*.

Another species of importance, as it occurs also in the upper carboniferous beds of China, is *Eumetria compressa*, Meek. This species also is rather closely allied to the shell under consideration. It seems, however, always to remain smaller, has less numerous ribs, and a laterally more compressed form. It does not seem suitable that *Eumetria grandicosta* should be united with that species.

II.—Group of *EUMETRIA ULOTRIX*, Kon.

2. Eumetria indica, Waagen: n. sp., Pl. XXXV, figs. 1, 2.

The general outline of this species is more or less globular, about as broad as it is long, and with strongly inflated valves. Both valves are ornamented by a few very strong and very coarse radial plications.

The ventral valve is generally strongly inflated and shows a very regular curve. The beak is thick, prominent, and very little curved, bearing on its dorsal side a comparatively large triangular area which is limited below by the straight hinge-line. The apex is truncated by a rather small round foramen. The valve is generally ornamented by eight, rarely by ten, coarse radiating folds, which are rounded on top, and are separated by equally broad but somewhat sharper furrows, of which the median one is very slightly broader and deeper, causing thus a barely perceptible sinus to be formed.

The dorsal valve is equally strongly and regularly vaulted as the ventral one. It is limited above by the short straight hinge-line, and is covered by seven, rarely by nine, coarse radiating folds, of which the median is largest.

The surface of the shell is nearly quite smooth, and only near the margins there are some more strongly marked striæ of growth. The punctation of the shell can be seen also in this species only with great difficulty and never very distinctly.

The internal characters of this species seem to be very similar to those of the preceding one, but they could not be made out so thoroughly.

The measurements of two specimens, No. I from Katta, No. II from Nursing-Pohàr, are as follow:—

	I.	II.
Entire length of the shell	10 mm.	9 mm.
Length of the smaller valve	8·5 „	8 „
Entire breadth of the shell	8·5 „	7·5 „
Thickness of both valves	8 „	5·5 „
Apical angle of the larger valve	85°	80°
„ „ „ smaller valve without the wings	110°	114°

No. I represents the typical shape, and No. II a more finely plicated and thinner variety.

Locality and geological position.—This species, in opposition to the preceding one, has a very limited geological range. It occurs only in the lowest beds of the middle division of the Productus-limestone, and has been found in these beds by myself at Katta,—bed No. 12 of my note-book,—(six specimens), at Amb (three specimens), and at Nursing-Pohàr (one specimen). By Mr. Wynne it has been brought from Morah (one specimen).

A single specimen was collected by me at Amb in the black coaly sandstone at the base of the lower division.

Remarks.—This species is most nearly related to *Eumetria grandicosta* described above, but can be distinguished from that species by its coarse ribs and differently

developed beak. Of other species only *Eumetria ulotrix*, Kon., is similarly coarsely ribbed, but is different from the present species by a much thinner and less prominent beak, and a broader general outline.

I am aware of no other species to which the present one could be more particularly compared.

Sub-family: *UNCITINÆ.*

Genus: UNCINELLA, Waagen, n. gen.

This genus is but very imperfectly known to me; nevertheless I cannot but distinguish generically what I subsume under the name.

In external shape the genus bears resemblance in a general way to *Retzia*. The valves are more or less finely plicated; no sinus or median fold is developed; the hinge-line is curved; the beak thick and strongly bent over, mostly appressed to the cardinal part of the dorsal valve; not provided with an area on its dorsal side, but bearing a distinct deltidium. It is pierced behind the apex by a large oval foramen. The apex of the dorsal valve is very strongly bent over, and partly concealed under the apical part of the ventral valve.

The internal characters could only partly be made out. The shell bears spirals of the same general disposition as in *Retzia* or *Uncites*, but neither the loop nor the mode of junction of the primary lamellæ with the crura could be made out definitely. What I could make out were the following points:

In the ventral valve, below the apex of the beak, there is an excavated small but very distinct deltidium; its composition of two pieces cannot, however, be made out. It does not reach down to the hinge-line, but is cut out below for the reception of the apex of the smaller valve. On both sides of the deltidium extend along the curved hinge-margin two long ridge-like hinge-teeth. They are not supported by dental plates, and there is also not a trace of other partitions.

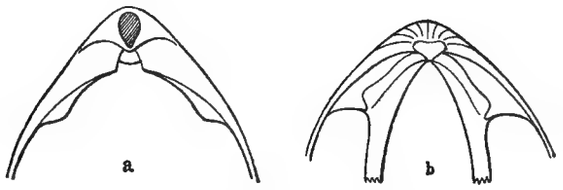


Fig. 8, UNCINELLA INDICA, Waagen, n. gen. et sp. Apical part of bot valves of two specimens from Amb and Nursing-Pohàr: *a*, ventral valve; *b*, dorsal valve;—both figures enlarged.

In the dorsal valve the apex is flattened, as if ground down, and bears a flat triangular space, as if for the insertion of muscles; a cardinal process is not present. At the apex two sharp ridges take their origin, limiting the dental sockets on the inner side. These latter are elongated deep triangular grooves. There is no hinge-plate spread out between the sockets. The crura take their

origin immediately at the apex, as thin shelly plates sloping strongly towards the middle line, and thus very nearly reach the bottom of the valve. As far as the dental sockets extend, these crural plates are fastened to them. Lower down they become free, and then form rather broad shelly blades, which always retain their sloping position towards the middle line of the valve. They are sunk deeply into the interior of the valve, extending not very far from the bottom of it.

It has not been possible for me to follow these parts further, as my materials were too scanty and too badly preserved; but from the general arrangement of the parts which I was able to study in detail, it becomes highly probable that the primary lamellæ of the spirals were not joined to the crura under a more or less acute angle as in *Retzia*, but that they formed simply the continuation of the crura as in *Uncites*. This is one of the reasons why I have placed this genus in the sub-family *Uncitinæ;* another is the great incurvation of the apical part of the dorsal valve. This position of the genus can, however, only be proposed in a provisional way, as the data regarding the internal character are insufficient to form a definite judgment on the point. Nevertheless, so much seems to be certain, that we have to deal here with a genus which is distinct from *Retzia*, the only genus with which the shells under consideration might possibly have been united. The absence of an area in the ventral valve, the absence of a hinge-plate and septum in the dorsal valve, and the broadness and sloping disposition of the crura, are all characters which make a generic distinction between these shells and *Retzia* unavoidable.

The genus is represented in the Salt-range only by a single species, which is very rare and occurs only at the base of the middle division of the Productus-limestone. This species shows, however, a very great similarity to some European shells, and it is highly probable that these also belong to the same genus. They are *Retzia carbonaria*, Dav., and *Retzia serpentina*, Kon. Of none of these species could I obtain specimens for comparison, as both are very rare, but chiefly from Davidson's excellent drawings of the first of the two species it becomes highly probable that they represent something very much like the Indian shells. Already Mr. Davidson was very much in doubt as to the generic position of this shell, and expressed the opinion that it possibly might be considered as belonging to Hall's genus *Rhynchospira*, which is distinct from *Retzia* by the absence of an area. The recent investigations on that genus undertaken by Messrs. Norman, Glass, and Davidson have, however, shown that *Rhynchospira* is in all particulars of internal arrangement identical with *Retzia*, and thus it does not seem possible to unite the Indian shell with Hall's genus, and also *Retzia carbonaria* will probably not belong to it.

1. Uncinella indica, Waagen : n. gen. et sp., Pl. XXXV, fig. 3.

The general outline of the shell is elongately oval with very strongly inflated valves, a straight front-line and a thick, not very prominent, beak. Both valves are covered with numerous rounded ribs.

The ventral valve is strongly inflated, with a very equal curve in both directions. The beak is very thick, not prominent, strongly bent over and entirely appressed to the apical part of the dorsal valve, so that the deltidium is entirely concealed. There is no area present, and even a false area is barely developed, though on both sides of the beak smooth spaces without radial ribs extend. These are, however, so sloping and so little marked off from the remainder of the valve, that they barely can be considered as forming a false area. The foramen is large and oval, piercing the beak behind its apex, and is generally more or less sloping in its position, rarely quite vertical, as it is represented in the drawing—pl. XXXV. The margins of the valve are quite straight, forming a minutely denticulated zigzag line.

The dorsal valve is perhaps slightly more strongly vaulted than the ventral one, but its curve is equally regular in both directions. The apex is very strongly incurved, and covered up for a distance by the beak of the opposite valve. Otherwise the margins are quite straight and minutely denticulated as in the other valve.

Each valve is ornamented with thirty to thirty-one radial ribs, which are broadly rounded on top, and separated from each other by narrow sharp furrows. Striæ of growth crossing over them cannot be detected.

The structure of the shell is very minutely punctate, and even with a very powerful lens the punctation can be seen only with difficulty.

The interior arrangement, as far as it could be made out, has been indicated already in the description of the genus.

It is not possible for me to give here exact measurements of the species, as not one of the specimens is sufficiently well preserved to take all the measurements. The figures on pl. XXXV have been drawn from a specimen from Nursing-Pohàr, in which the frontal part is injured, the drawing being completed from a specimen from Katta.

Locality and geological position.—This species is restricted to a single bed of the Productus-limestone, forming the lowest bed of the compact limestones, of which the middle division of the Productus-limestone is for the greater part composed. This bed is sometimes black and sandy, as at Nursing-Pohàr, where I collected three specimens of the species; sometimes it is greyish yellow and marly, as at Katta, where I collected one specimen; and sometimes it is a reddish yellow silicious marble, as at Amb, where I also found one specimen.

Remarks.—The species is very markedly distinct from all the others occurring in the Salt-range. The shell which it most resembles is *Retzia carbonaria*, Dav., but also from this species it is not difficult to distinguish it. Its general shape is much more robust than *Retzia carbonaria*, and it has much more inflated valves. Its striation is finer and the beak much more firmly appressed to the apical part of the smaller valve; there can be no doubt that the Indian shell is quite distinct from the English one.

Of other species, *Retzia vera*, Hall, is of about equal size, and has a similar general outline; but the presence of a small area below the beak and the straight hinge-line assign it necessarily to quite a different genus.

The other two species which might yet be compared, *Terebr. marcyi*, Shum., and *Retzia serpentina*, Kon., are much less robust and also otherwise easily distinguishable.

Family: *SPIRIFERIDÆ*, King.

This is one of the most natural families that exists; not only by the internal characters can the shells belonging to it be recognised, but also the external shape is so very characteristic that by it alone the members of the family may be discerned.

Of the external characters the most striking ones are the long straight hinge-line and the more or less large and distinct area. The internal ones consist in the circumstance that the crura and the primary lamellæ form one tolerably continuous piece as in *Uncites;* in the very insignificant development or entire absence of a loop; and in the more or less strongly developed septa, which are only exceptionally absent in the ventral valve.

In this family also Mr. Davidson has distinguished a number of groups, most of which can be considered as forming natural sub-families. Yet I should like to propose some changes in the grouping of the several genera.

The group of forms which most nearly approaches in its internal arrangement the family *Nucleospiridæ* is that of which *Spiriferina*, Orb., is the type. In this group the primary lamellæ are still connected by a transverse shelly band as in *Uncites*, and the shell is punctate as in *Retzia*. That *Suessia*, notwithstanding its fibrous shell, belongs to the same group cannot be doubted. *Cyrtina*, Dav., has the loop very much as in *Spiriferina*, and I should not like to create a proper sub-family for the reception of that genus. I am thus inclined to consider these three genera as forming one sub-family under the name of SUESSIINÆ, as the other two generic names included in the sub-family are not well adapted for the creation of sub-family designations. In this sub-family may perhaps be included the genus *Mentzelia* of Quenstedt.

A second natural sub-family is formed by the first group, as distinguished by Davidson. The genus *Spirifer* represents the type of this sub-family. The loop is no longer complete in these forms, but consists only of two spurs, which originate at the primary lamellæ, and converge towards the middle without ever uniting. The genus which seems next to approach the sub-family *Suessiinæ* is *Syringothyris*, Winchell; then comes *Cyrtia*, Dalm.; and then *Spirifer*, Sow. These three genera compose together a sub-family, for which I shall introduce the name of "DELTHYRINÆ."

From *Spirifer* proper must be separated the smooth forms with a small area. Except in their general shape they are distinct from *Spirifer* by an external coating with a neat and distinct punctation. The internal characters of this group are not sufficiently well known in all the species to draw conclusions from them. On the whole, two generic groups can be distinguished; one with a thin shell and devoid of

internal partitions—this forms the old genus *Martinia*, M'Coy; and one with a thick shell, strong dental plates and shelly supports for the dental sockets, for which I shall introduce the name of *Martiniopsis*. Both can be united conveniently in a proper sub-family, for which I shall introduce the name of MARTINIINÆ.

The existence of a fourth sub-family, of which the genus *Reticularia* is the type, has been indicated already by Davidson. The forms belonging to it are characterised by hair-like processes, which project from the surface of the shell. Interiorly all the shells belonging to this sub-family are devoid of partitions in the ventral as well as in the dorsal valve. Of a loop there is not the slightest trace, and even the spur-like processes which ornament the primary lamellæ of the spirals in *Spirifer* are entirely absent. There are two generic groups distinguishable within this sub-family: the genus *Reticularia*, M'Coy, in which the hair-like processes of the shell are arranged in concentric rows; and the genus *Ambocœlia*, Hall, in which the hair-like processes occur irregularly over the whole surface of the shell. I shall introduce for this sub-family the name of "RETICULARIINÆ."

The geological distribution of the several genera has been indicated already by Davidson. I only would remark here that the genus *Cyrtina* reaches up into the uppermost triassic beds, into the rhætic, where *Cyrtina uncinata*, Schafh., is a very characteristic representative of the genus; and that the genus *Reticularia* is not restricted to the devonian and carboniferous formations, but extends also up into permian beds, in which latter formation it has been detected by Abich in Armenia.

Sub-family: *SUESSIINÆ*, Waagen.

Genus: SPIRIFERINA, Orb.

This genus is characterised by several easily observable features. The most striking external character is the punctured condition of the shell, which is in many cases so strongly developed that one would almost take the shell to be covered with the minute cells of some Bryozoon. The punctures are, however, differently disposed in different species; sometimes they very closely approach each other, sometimes they are more than five and six times their own diameter distant from one another. If the shell is very well preserved, it is covered by a thin coating, with small granules where the pores terminate under the coating.

Internally the ventral valve bears besides the strong dental plates a more or less high median septum, which can often be seen within the triangular fissure below the beak. Near the apex this septum is for a more or less small distance firmly grown together with the pseudo-deltidium, which covers part of the triangular fissure.

The dorsal valve bears a small area, and there is a more or less large cardinal process within the apex of this valve. The dental sockets are supported by strong septa, and also a small median septum is mostly present. The crura are fixed to

the socket-walls, and united by a transverse shelly band where the primary lamellæ of the spirals are joined to them.

The genus begins already in the higher beds of the silurian period and extends up through all the formations to the lias.

In the Salt-range the genus is largely represented. The most numerous species is *Spiriferina cristata*, Schloth. sp. It extends through all the beds of the formation from top to bottom. All the other species are much rarer; they are *Spiriferina multiplicata*, Sow.; *Sp. ornata*, Waagen; *Sp. nasuta*, Waagen; and *Sp. vercherei*, Waagen.

These five species may be grouped in the following manner :—

I.—Group of Spiriferina lima, Quenst.
1. *Spiriferina cristata*, Schloth. sp.
2. „ *multiplicata*, Sow.
3. „ *nasuta*, Waagen, n. sp.

II.—Group of Spiriferina insculpta, Phill.
4. *Spiriferina ornata*, Waagen, n. sp.

III.—Group of Spiriferina transversa, M'Chesn.
5. *Spiriferina vercherei*, Waagen, n. sp.

Of these species only two occur also in Europe,—*Sp. cristata* and *Sp. multiplicata*. The former is there most numerously represented in the carboniferous formation, and extends up into permian beds. I perfectly agree with Mr. Davidson that the carboniferous and permian shells are specifically identical. I am less certain whether the devonian specimens similar to *Sp. cristata* should be united with that species. They have been distinguished by Quenstedt under the name of *Sp. lima*, and I for the present retain that name.

The second species that is common to Europe and India is *Sp. multiplicata*, Sow. Mr. Davidson is inclined to consider this species also as only a variety of *Sp. cristata*, Schl. (or *Sp. octoplicata*, Sow.), and even figures such a specimen from India under the name of *Sp. octoplicata*, Sow., in Vol. XVIII of the Quarterly Journal; but I cannot concur with the learned author in this respect. In *Sp. multiplicata* the shell structure is very different from that of *Sp. cristata*, and this in combination with the different general outline is, I think, quite sufficient to distinguish specifically between the two forms. So far as I am aware, *Sp. multiplicata* has hitherto been found in Europe only in permian beds.

I.—Group of *SPIRIFERINA LIMA*, Quenst.

1. Spiriferina cristata, Schloth.: Pl. XLIX, figs. 3-7.

1816. *Terebratulites cristatus*, Schlotheim: Denkschr. Acad. d. W. zu München, 1816, p. 28, pl. I, fig. 3.
1827. *Spirifer octoplicatus*, Sowerby: Min. Conch., p. 120, pl. 562, figs. 2, 3, 4.
1850. *Trigonotreta cristata* (Schl.), King: Monogr. Brit. Perm. Foss., p. 127, pl. VIII, figs. 9—14.
1858. *Spiriferina cristata* (Schl.), Davidson: Monogr. Brit. Perm. Brach., p. 17, pl. I, figs. 37—40, 45, 46; pl. II figs. 43-45.

1858. *Spiriferina cristata, var. octoplicata,* Davidson: Monogr. Brit. Carb. Brach., p. 38, Pl. VII, figs. 37—47.
1861. *Spirifer cristatus,* (Schl.), Geinitz: Dyas, II, p. 88, pl. XVI, figs. 8—10.
1862. *Spiriferina octoplicata* (Sow.), Davidson: Quart. Jour., Geol. Soc., Lond., Vol. XVIII, p. 29, pl. I, figs. 12 13, 14 (non pl. I, fig. 11).
1863. *Spiriferina octoplicata* (Sow., Dav.), Koninck: Foss. paléoz. de l'Inde, p. 36, pl. X, figs. 12, 13, 14 (non pl. IX, fig. 11).
1863. *Spiriferina cristata=Sp. octoplicata,* Dav.: Monogr. Brit. Carb. Brach., p. 267, pl. 54 figs. 10-13.
1865. *Spirifer cristatus* (Schl.), Beyrich: Kohlenkalk-Fauna von Timor, p. 79, pl. I, fig. 4.

The Indian specimens of this species seem to deviate in some slight degree from the figures given by Davidson, and therefore a description of them seems not to be out of place.

The general outline is variable as in the European specimens, the greatest breadth being, however, nearly always situated at the hinge-line; among nearly fifty specimens there are only three in which the greatest breadth is situated a little more towards the front. The area is large and forms a very low angle (of about 120° to 150°) with the plane of the dorsal valve. Specimens like the one represented by Davidson, figs. 42 and 43, I have never observed in the Salt-range.

The ventral valve is always equally deep and vaulted as the dorsal one. The beak is thin, strongly pointed and well bent over. The area is quite smooth and shows no vertical striation. The punctation extends on the area as well as on the remaining surface of the shell. The triangular fissure is rather small, and only at its uppermost extremity covered by a very small deeply sunk pseudo-deltidium, which is in the middle grown together with the vertical median septum. The plications are nearly always very high and narrow, and are separated from each other by furrows having the same breadth as the folds. The number of these folds varies between 8 and 14. The sinus is deep and rounded, not quite twice as broad as the furrows between the adjoining folds, and sometimes with a slight trace of a median fold.

The dorsal valve has generally only a very narrow area, which in many cases is quite linear. The curvature of the valve is equal to that of the ventral valve. The number of folds on this valve varies between 8 and 19. The median one is by far the strongest and most prominent, and represents the median fold, corresponding to the sinus of the other valve. It is slightly but very indistinctly flattened on top. Otherwise the character of the folds is the same as that of the folds on the opposite valve.

The substance of the shell is very coarsely punctate. There are generally not more than four punctures to the space of one millimetre, so closely set that they nearly touch each other. They are arranged in quincunx. Each puncture is the entrance to a canal, which traverses the substance of the shell in a slightly oblique direction. If the surface of the shell is quite intact and not modified by weathering, the orifice of each canal is shut as with a cover by a small lenticular or globular calcareous body. The outer surface of the shell appears then as if closely papillate. On the inner surface the canals are always open. The canals are, however, entirely limited to the outer parts of the shell, the septa and all the shelly parts within the valves are devoid of the punctate structure.

I regret to say that my time was too limited to subject this species to a close examination as to its internal characters. What has been occasionally observed by me seemed to be in accordance with the characters generally attributed to the species belonging to the genus.

The measurements of two specimens, No. I from Katta with twelve folds on the dorsal valve, the other No. II from Swás with nine folds on the same valve, are as follow :—

	I.	II.
Entire length of the shell	17 mm.	14 mm.
Length of the smaller valve	13 „	11 „
Entire breadth of the shell at the hinge-line	23·5 „	20 „
Thickness of both valves	13 „	10 „
Apical angle of the larger valve at the apex	125°	112° „
„ „ „ smaller valve	137°	130° „

There are some fragmentary specimens, which apparently, if complete, would exhibit slightly larger dimensions than No. I, but the difference is not very great, and the species seems never to have attained considerable dimensions.

Locality and geological position.—This is a wide-spread but never very abundant species in the Salt-range.

It has been collected in the lower division of the Productus-limestone at Amb in the so-called *Chonetes* bed (seven specimens).

In the middle division it has been found by Dr. Oldham and Dr. Warth at Swás (two specimens) and at Musakheyl (two specimens). By myself it has been brought from Khúra from the lower limestone series (one specimen), and from the top of the calcareous series (six specimens), and on the road between the Chidru and Golawáli (one specimen). At the base, in the very lowest beds of the middle division, it has been collected by myself at Katta (bed No. 12 of my note-book) two specimens, at Amb one specimen, and at Nursing-Pohár one specimen; Trans-Indus the species has been found by myself at Káfirkot (nine specimens), and by Mr. Wynne, north of Káfirkot (three specimens).

In the upper division of the Productus-limestone the species has been collected by myself at Jabi in the Cephalopoda bed (six specimens), and at Chidru in the same bed (two specimens). One specimen I found at the base of the upper division in the section west of Khúra.

In the top beds of the whole formation, which have furnished among the bivalves so many characteristic forms, I observed the species at Virgal.

I must also state here that no particular variety is characteristic for a single bed, but that specimens with many and with few folds, with a high and with a narrow area, &c., are found quite promiscuously.

Remarks.—From the description given above it will appear that the specimens from the Salt-range agree in all important points with the European species, and that there appears not to exist sufficient reason to consider the Indian shells as a distinct species. It is true that some characters indicated by Davidson as frequently occurring in European specimens have not been observed by me in the

Indian shells,—as, for instance, the secondary ribs which occur at the sides of the median fold in the dorsal valve have never been observed in Indian specimens; but this and like discrepancies are certainly too small to be taken heed of. The greatest difference seems to consist in the generally greater sharpness and height of the ribs. In this respect the Indian shells are more akin to that figured by Beyrich from Timor than to Davidson's drawings.

On the whole, the determination of these specimens as *Spiriferina cristata* cannot be far wrong, and it is in accordance with the views of Mr. Davidson.

2. Spiriferina multiplicata, Sow., sp.: Pl. XLIX, figs. 8-9.

1829. *Spirifer multiplicatus*, Sowerby: Geol. Transact., 2nd series, Vol. III, p. 119.
1850. *Trigonotreta multiplicata* (Sow.), King: Mon. Brit. Perm. Foss., p. 129, Pl. VIII, figs. 15-18.
1858. *Spiriferina multiplicata* (Sow.), Davidson: Mon. Brit. Perm. Brach., p. 19., Pl. I, figs. 41-44.
1861. *Spirifer curvirostris* (Vern.), Geinitz: Dyas, II, p. 89, Pl. XVI, figs. 12-13 (non Vern.).
1862. *Spiriferina octoplicata* (Sow.), Davidson: Quart. Journ., Geol. Soc., Vol. XVIII, Pl. I, fig. 11 (non figs. 12-14).
1863. *Spiriferina octoplicata* (Sow., Dav.), Koninck: Fossiles paléoz. de l' Inde, Pl. IX, fig. 11.

The general outline of this species is nearly globular, length and breadth being about equal, and the thickness not much smaller. There is a distinct, rounded, but not very deep, sinus in the ventral and a corresponding median fold in the dorsal valve. The lateral parts of the shell are covered by rounded and not prominent folds.

The ventral valve is strongly inflated and equally curved in both directions. The sinus begins already at the very apex, long before the lateral folds are developed. The beak is not very thin, pointed, and well bent over. The area is slightly concave and not very distinctly marked off from the remainder of the shell. The triangular fissure is comparatively large. The hinge-line is straight and shorter than the greatest breadth of the shell. The sinus is broad, not deep and rounded. On each side of the sinus are mostly four, sometimes six folds, which sometimes, however, become so little marked as almost entirely to disappear, so that then the valve, with the exception of the excavated sinus, is nearly quite smooth.

The dorsal valve is not less inflated than the ventral one, and its curve is equal in both directions. The apex, though apparently not prominent, yet distinctly overhangs the straight hinge-line, whereby a narrow but distinct area is formed, which bears in the middle a broad triangular fissure. Already at the apex begins the distinct rounded and not very strongly prominent median fold, which is on both sides limited by minor flatly-rounded plications covering the lateral parts of the valve. Three to six of these plications come on each side, but they become sometimes so very low that the shell appears nearly smooth.

The surface of each valve is covered by very fine striæ of growth, of which some are more strongly marked and imbricating. The shell substance is very finely granulated, as finely as in any species of *Terebratula*. There are eight to ten granules on the space of one millimetre, and the canals which pierce the shell are

so very narrow that they cannot be distinguished with a common lens. The granulation is arranged beautifully in quincunx.

I have not been able, on account of the scarceness of specimens, to ascertain the internal characters of this species.

The measurements of a very complete specimen from Jabi are as follow :—

Entire length of the shell	14 mm.
Length of the smaller valve	11 „
Entire breadth of the shell	14·5 „
Length of the hinge-line	11·5 „
Thickness of both valves	12 „
Apical angle of the larger valve	95°
„ „ „ smaller valve	112°

There are some specimens from Musakheyl, which seem to have attained slightly larger dimensions.

Locality and geological position.—This species is rather rare in the Salt-range, and restricted to certain horizons. It first appears in the uppermost beds of the middle division of the Productus-limestone, and has been collected in these beds by Dr. Warth at Musakheyl (three specimens). I have myself only found the species in the upper division at Jabi, in the Cephalopoda bed (four specimens), and in the same bed at Chidru (one specimen).

Remarks.—The species has not been entirely admitted by Davidson, but he expresses the opinion that it might very probably be united with *Spiriferina cristata*, and he mentions also that Prof. King inclined to the same opinion. In his note on the fossils brought by Dr. Fleming from the Salt-range, Mr. Davidson figures a specimen belonging to this species directly under the name of *Spiriferina octoplicata*. Notwithstanding this I cannot but retain the specific denomination of *Spiriferina multiplicata* for the shells here under consideration. Mr. Davidson remarks in his description of the species : "The canals are (stated by Mr. Howse to be) smaller than those in *Sp. cristata*;" and indeed the difference in the shell structure of the two species is so great that there cannot be the slightest doubt of their being assignable to different species. Whilst in *Spiriferina cristata* the canals are so wide that they can generally be distinguished with the naked eye, in *Spiriferina multiplicata* they are as small as in any species of *Terebratula*, and can be distinguished only with a powerful lens.

It cannot, I think, be seriously doubted that the Indian specimens belong to Sowerby's species. The only difference that I can detect consists in the less distinctly marked striæ of growth in the Indian specimens, but it appears to me that this circumstance is not sufficient to make a distinct species of them.

The identification of this species is of geological interest, as it occurs in Europe only in permian beds, and has, as far as I am aware, not yet been detected in the carboniferous period.

I cannot close the remarks upon this species without drawing attention to the fact, how closely it resembles the *Spiriferina verrucosa* of the middle lias.

3. SPIRIFERINA NASUTA, Waagen: n. sp., Pl. XLIX., figs. 1-2.

This species attains somewhat larger dimensions than the two which have been described previously.

The general outline is transversely oval with a large, prominent, nose-like median fold and coarse radial plications on the lateral parts. The area is flat and reclining, and tolerably high.

The ventral valve is not very strongly inflated, and its bend is not strong in either direction. The beak is pointed, not bent over and very short; the area very broad, triangular, flat and reclining, forming an angle of about 125° with the plane of the dorsal valve. The deltidial fissure is not very broad. The sinus of the valve is very broad, but not very deep, and at a short distance from the apex a broad rounded rib begins to appear in the middle of it, which gets stronger and more prominent as it approaches the margin of the valve. It causes the frontal margin to ascend very strongly, and to project in a long pointed process above the plane of the valve. On each side of the sinus there are four broad coarse folds, rounded on top and separated from each other by equally broad rounded valleys.

The dorsal valve is not more strongly vaulted than the ventral one, and its curve is also equal in both directions. The apex is very little prominent and the area extremely narrow. The hinge-line is straight and about as long as the greatest breadth of the shell. The median fold is not very broad, but extremely prominent, its top being nearly quite straight and not partaking in the general curvature of the valve. On both sides of the median fold there are four coarse, broad, rounded, radiating folds, which decrease in size as they approach the hinge-line.

The surfaces of both valves show from distance to distance strong imbricating striæ of growth, which become heaped together in greater numbers at the margin of the shell.

The substance of the shell is very coarsely punctate, even more coarsely than in *Spiriferina cristata*, and the punctation, if tolerably well preserved, can easily be seen with the naked eye. On fractures of the shell the canals can easily be seen piercing the shell in great numbers in an oblique direction.

The materials of this species were too scanty to make out any of the internal characters.

The measurements of two specimens from Morah, as far as they could be made out, are as follow :—

	I.	II.
Entire length of the shell, about	29·5 mm.	20 mm.
Length of the smaller valve	23 „	17 „
Entire breadth of the shell, about	31 „	22 „
Thickness of both valves	19 „	13 „
Apical angle of the larger valve	130°	123°
„ „ „ smaller valve	146°	145°

The specimen No. I is the largest that has been detected up to the present,

Locality and geological position.—This is a very rare species, and has been found only by Mr. Wynne in the very hardest marble-like silicious limestones of the middle division of the Productus-limestone. There are altogether only five specimens of the species known to me, of which four were collected by Mr. Wynne at Morah and one at Chidru.

Remarks.—All the specimens of this species are rather poorly preserved on account of the extreme difficulty of extracting them from the rock. The nose formed by the prolongation of the frontal part is always broken off.

There is no doubt that this species must be assigned to the same group of forms as *Spiriferina cristata*, but it is quite as certain that the two species are specifically distinct. The larger size, the extremely prominent median fold, the thick prominent rib in the middle of the sinus, and the great coarseness of the radial folds, —all these characters make a distinction from *Spiriferina cristata* most easy, and there is, I think, but little doubt that we have to deal here with a well-distinguishable and characteristic new species.

II.—Group of *SPIRIFERINA INSCULPTA*, Phill.

4. Spiriferina ornata, Waagen: n. sp., Pl. L., figs. 1-2.

The general outline of this species is transversely oval with a hinge-line somewhat shorter than the greatest breadth of the shell. Both valves bear coarse sharp folds, ornamented by a very fine concentric sculpturing, which consists of closely arranged lamellæ.

The ventral valve is slightly more strongly curved and deeper than the dorsal one; its curvature is equal in both directions. The area is high and concave, limited below by the not very long straight hinge-line. The triangular fissure is not very large. The beak is thick, short and well bent over. The sinus is deep, angular and tolerably broad. On each side of it there are three to five high narrowly rounded ribs, separated from each other by angular valleys. The concentric sculpturing extends over these ribs following the outline of the margin of the valve and thus forming zigzag lines.

The dorsal valve is flatter than the ventral one; it is not very strongly curved in the longitudinal, more so in the transverse, direction. The apex is very little prominent, and the area extremely narrow. The valve is covered by seven to nine very high and sharp ribs, of which the median one is the highest and most prominent, corresponding to the sinus of the opposite valve, and representing the median fold. The ribs are, as on the other valve, narrowly rounded on the top and separated from each other by angular valleys. The concentric sculpturing is the same as on the other valve.

The substance of the shell is rather coarsely punctate in a similar manner as in *Spiriferina cristata*.

The species is very rare, and thus it has not been possible for me to ascertain its internal characters.

The measurements of a specimen from Chidru are as follow :—

Entire length of the shell	16 mm.
Length of the smaller valve	11 „
Entire breadth of the shell	17·5 „
Length of the hinge-line	15 „
Thickness of both valves	15 „
Apical angle of the larger valve	107°
„ „ „ smaller valve	147°

Locality and geological position.—There are altogether only three specimens of this species known to me. Two of them were collected by me at Chidru in the top bed of the upper Productus-limestone, together with all the Pelecypoda described in a former part of this work, and the third I found in the Cephalopoda bed at Jabi. The species seems thus to be restricted to the upper division of the Productus-limestone.

Remarks.—In its general configuration this species is very similar to *Spiriferina cristata*, and in this respect it might rather be united with the group of forms to which that species belongs. But to such an allocation the sculpturing is averse, and on account of this character it seems to be more closely allied to *Spiriferina insculpta*, Phill., than to any other species. From the latter form, though the sculpturing of both is identical, the Indian shell can easily be distinguished by a different general outline, a shorter hinge-line, a higher median fold and corresponding sinus, a concave area, &c.

Spiriferina insculpta is a carboniferous species, but begins, according to Davidson, already in the devonian period. This fact has, however, been called into doubt by Quenstedt, who says that the devonian shell is a *Cyrtina*.

III.—Group of *SPIRIFERINA TRANSVERSA*, M'Chesn.

5. Spiriferina vercherei, Waagen: n. sp., Pl. XLVIII, fig. 3.

The general outline of this species is very elongately transverse, with an extremely long hinge-line and pointed wings. The valves are covered by tolerably coarse radiating ribs, the median fold is not very prominent, the area not very broad.

The ventral valve is longitudinally not much vaulted, and transversely its curvature is still less considerable. The area is very elongately triangular, somewhat concave and covered by a fine vertical striation, which is crossed by as fine striæ of growth, extending parallel to the hinge-line. The triangular fissure is tolerably broad; a pseudo-deltidium could not be observed. The beak is thin, strongly pointed and well bent over. The sinus is broad, tolerably deep and smooth. It begins already at the apex of the beak. On both sides of the beak there are six to seven radiating folds with rounded tops, separated from each other by rounded valleys.

The dorsal valve is not more strongly vaulted than the ventral one, and its longitudinal, as well as its transverse, curvature is very small. The apex is little prominent, and the area for its greater extent nearly linear. The median fold is already

distinctly marked at the apex, but lower down it is not very prominent. It has a very broadly-rounded top, and is rather broad at its base. On each side of the median fold there are seven coarse radiating ribs of the same description as those of the other valve, the last of them being nearly parallel to the hinge-line.

Both valves are ornamented from distance to distance by not very strongly marked imbricating striæ of growth, which are heaped together in great numbers near the margins.

The structure of the shell is coarsely punctate as in *Spiriferina cristata*, but the punctures are not arranged in quincunx, but in irregular rows, which approximately follow the direction of the striæ of growth.

The internal characters of the species are not known to me.

The dimensions of the only specimen are as follow:—

Entire length of the shell	21 mm.
Length of the smaller valve	17 „
Entire breadth of the hinge-line	45 „
Thickness of both valves	16 „
Apical angle of the larger valves	116°
„ „ „ smaller valve	136°

Locality and geological position.—There is only a single specimen of this species and its exact locality is not known. The specimen was in Dr. Verchere's collection, and is preserved in a yellow sandy marly rock; there is but very little doubt that it comes from the upper division of the Productus-limestone of the Rotta Roh ridge in the Trans-Indus continuation of the Salt-range.

Remarks.—Though only a single specimen of this species is known to me, yet its general shape is so characteristic and interesting that I thought it well worth while to describe it and give it a proper specific designation.

There is no European species to which the present one could be more particularly compared. From American localities, however, shells have been described which bear a more or less close resemblance to the present species: they are *Spiriferina transversa*, M'Chesney, and *Spiriferina kentuckensis*, Shumard; the former seems to be more closely related. The American species, however, apparently never attains so large dimensions as *Spiriferina vercherei*; the chief difference seems to consist in the presence of a rib in the middle of the sinus of *Spiriferina transversa*, and in the altogether coarser plications of our Indian shell.

On the whole, it is not without interest to see here again an American type represented in the Indian strata.

Sub-family: *DELTHYRINÆ.*

Genus: SPIRIFER, Sowerby.

Though it appears that the genus *Spirifer* is one of those which are best known, I think some words of explanation may be needed as to the sense in which I here use the name.

The name was originally given to radially plicated forms, and for such it must be retained; while it seems to be of practical advantage to distinguish the smooth forms under a different designation. Such a distinction is not of a practical value only; it can be well supported on scientific grounds. The shell of the radially plicated forms is by general consent of all naturalists purely fibrous, whilst the shell of the smooth forms bears a distinctly punctate coating, as has been stated by Monsieur de Koninck, and as can be most decidedly affirmed from my own observations. I therefore shall restrict the name *Spirifer* to the plicated forms with a fibrous shell, and shall subsume the other forms under the name of *Martinia, &c.*

Spirifer proper may then be characterised in the following manner: Shell fibrous, externally ornamented by more or less distinct radial folds. Area more or less extended, triangular, but never as large as in *Cyrtia*. Internally there are two spiral cones the apex of which is directed approximately towards the lateral parts of the shell; the primary lamellæ of these cones are fixed directly to the socket walls; not far from their origin they give off two short spurs, directed towards the middle of the shell, which, however, never unite. In the ventral valve the hinge-teeth are supported by strong dental plates.

Thus limited the genus is not represented in the Salt-range by very numerous species. I count altogether not more than eight species, two of which were already known to Mr. Davidson,—*viz.*, *Spir. striatus*, Mart.; and *Spir. Musakheylensis*, Dav.: the other six species will respectively bear the names of *Spir. marcoui*, W.; *Spir. oldhamianus*, W.; *Spir. ambiensis*, W.; *Spir. wynnei*, W.; *Spir. alatus*, Schloth.; and *Spir. niger*, W.

These species may be grouped most conveniently in the following manner:—

I.—Group of Spirifer striatus, Martin.
1. *Spirifer striatus*, Martin.
2. *Spirifer marcoui*, Waagen.

II.—Group of Spirifer tegulatus, Trautschold.
3. *Spirifer Musakheylensis*, Davidson.
4. *Spirifer ambiensis*, Waagen, n. sp.

III.—Group of Spirifer duplicicosta, Phillips.
5. *Spirifer wynnei*, Waagen, n. sp.

IV.—Isolated species.
6. *Spirifer oldhamianus*, Waagen, n. sp.

V.—Group of Spirifer triangularis, Martin.
7. *Spirifer alatus*, Schlotheim.
8. *Spirifer niger*, Waagen, n. sp.

Of all these species only two occur also in Europe: these are *Spirifer striatus*, Mart.; and *Spirifer alatus*, Schloth. The first is a common species of the mountain-limestone; in India it is, however, anything but common. Among the really extensive materials of Salt-range fossils in my hands, there is not a single complete specimen of the species. It occurs exclusively in the lower division of the Productus-limestone, and is extremely rare there. The second species, *Spir. alatus*,

Schl., is not much more common than *Spirifer striatus*. In Europe it is a species of the permian formation, and in India it occurs in the lower division of the Productus-limestone. The group is better represented in India by *Spirif. niger*, which is very nearly related to *Spir. alatus*, and seems here to replace that species.

Another species of geological interest is *Spir. marcoui*, W. This is a characteristic species of the American coal-measures. It occurs in India also in the lower division of the Productus-limestone.

I.—Group of *SPIRIFER STRIATUS*, Mart.

1. Spirifer striatus, Martin: sp., Pl. XLIV, figs. 3, 4, 5.

1809. *Anomites striatus*, Martin: Petr. Derb., tab. XXIII.
1820. *Spirifer striatus* (Mart.), Sowerby: Min. Conch., pl. 270.
1843. *Spirifer striatus* (Mart.), Koninck: Descr. Anim. foss. de la Belg., pl. 25 bis., fig. 4.
1858. *Spirifera striata* (Mart.), Davidson: Monogr. Brit. Carb. Brach., p. 19, pl. II, figs. 12-21; pl. III, figs. 2-6.
1862. *Spirifera striata* (Mart.), Davidson: Quart. Journ., Geol. Soc., Lond., Vol. XVIII, p. 28, pl. I, figs. 9, 10.
1863. *Spirifera striata* (Mart.), Davidson; Koninck: Foss. paléoz. de l'Inde, p. 34, pl. IX, figs. 9, 10.

It seems barely possible to draw up a description of this species from the very scanty and fragmentary materials at my disposal.

The best specimen is the small one represented in fig. 5, but it is too small to admit of a quite exact determination. Another specimen, in which both valves are partly preserved, is the one drawn in fig. 4; but this again has suffered so much from pressure that its determination is also not beyond doubt. All the other remaining material consists in more or less fragmentary ventral valves; one of these, the most complete one, is represented in fig. 3.

The characters of these ventral valves consist in a transversely elongated general outline with rounded corners. The valves are very flat, less convex than in all the European specimens of *Spirifer striatus* that are known to me. The beak is short, thick, pointed and little bent over. The area is moderately broad and concave. The triangular fissure is extremely broad, forming a triangle, the longest side of which is in the continuation of the hinge-line. The sinus is not very broad and rather shallow, shallower than in most of the specimens of the typical *Spirifer striatus*. The surface is covered with numerous somewhat broadish radiating ribs, which are slightly flattened on the top. Near the beak they are distinctly bundled, five bundles on each side of the sinus; lower down the bundling disappears almost entirely. The radiating ribs are crossed at irregular intervals by imbricating striæ of growth.

Of the internal characters nothing could be ascertained.

It would also be useless to give numerous measurements; only the indication of length, breadth and thickness of the most complete ventral valve will perhaps be of interest; it is from Gulámi. The measurements are as follow:—

Entire length	48 mm.
„ breadth	78 „
Thickness, the elevation of the sinus included . . .	19 „

Locality and geological position.—All the specimens of this species that are preserved in the Salt-range collection come from the sandstones of the lower division of the Productus-limestone. It has been collected by myself in greyish-yellow sandy strongly micaceous beds (No. 10 of my note-book) at Katta (two fragmentary specimens); at Amb in a black coaly sandstone forming the lowest fossiliferous bed above the lavender-clays (one specimen); and somewhat higher, in the dark sandstones composing the *Chonetes* bed (three specimens). Mr. Wynne brought the species from the Verála scarp (one specimen), from Dokri (one specimen); and Trans-Indus from Gulámi (three specimens). Dr. Oldham and Mr. Theobald collected it in the Chittawán (two specimens); Mr. Davidson quotes the species from Nulle and Chidru.

Remarks.—From the above list it appears that the species has a tolerably large geographical distribution in the Salt-range, but it is very strange that it always occurs in rather isolated specimens, and only in a fragmentary condition. Whilst in the same beds other species are entire and well preserved, *Spirifer striatus* is always fragmentary; what may be the reason of this I cannot say.

Peculiar to the Indian specimens is the great flatness of the ventral valves, the only ones which are sufficiently accessible to observation. As the specimens in all other respects perfectly agree with *Spir. striatus*, it is not possible to determine them otherwise; nevertheless this flatness may always be apt to cast some doubt on the identity of the Indian and the European specimens, and the fragmentary condition of the Indian materials does not enable us to remove these doubts.

2. Spirifer marcoui, Waagen: n. sp., Pl. XLVII.

1858. *Spirifer striatus*, (Mart.), Marcou: Geol. of North America, p. 49, pl. VII, fig. 2 (non Martin neq. Davidson).

The general outline of this species is somewhat transversely trapezoidal, with boldly curved valves, of which the dorsal is slightly deeper than the ventral one. Median fold and sinus are very strongly developed. Both valves are covered with a radial striation.

The ventral valve is very strongly curved in the longitudinal direction, but nearly flat transversely. The straight hinge-line is as long as the greatest breadth of the shell. The corners at the end of this line are sometimes sharply produced, sometimes not. The area is rather broad and flat, only very little concave, and shows in well-preserved specimens only an indistinct vertical striation. The triangular fissure is about as high as it is broad. The beak is thick, short, pointed and not strongly bent over. The sinus is very deeply sunk in, sometimes sharply impressed in the middle, sometimes rounded, begins very near the apex of the beak. Mostly it is not sharply marked off from the remainder of the shell, but in some cases it is limited on both sides by obtuse ridges. The radial striation is somewhat finer than in *Spirifer striatus*, Mart. There are generally from 20 to 30 ribs within the sinus and from 30 to 40 on each lateral part of the valve. The ribs show

mostly slight traces of bundling, chiefly in the region of the apex, but this character is never distinctly developed. All the ribs are crossed at irregular distances by strong imbricating marks of growth.

The dorsal valve is very strongly curved in the longitudinal direction on its lateral parts, but less strongly along the median fold. In the transverse direction the curve is strong and regular. The apex is tolerably prominent, the area not very small. The median fold is extremely high, but never quite sharp. It is mostly very narrowly rounded (as in figs. 1 and 2) and only rarely slightly broader (as in fig. 3). It begins at the very apex of the valve, but is rather indistinct there; at a short distance from the apex, however, it begins to become prominent. The number of radiating costæ is as large on this valve as on the other; the tendency to form bundles is still less marked in this valve than on the opposite one. In this valve also strong, imbricating, irregular marks of growth cross the radial striation.

The structure of the shell is, as far as I can see, entirely fibrous.

The internal characters could not be made out in this species. I may only remark here that the shell is often extremely thickened in the apical region, so that the dental plates in the ventral valve and the outer walls of the shell form altogether one shelly mass. This has then very often been corroded in a strange way before the specimens were imbedded.

The measurements of two specimens from Pail are as follow :—

	I.	II.
Entire length of the shell	58 mm.	53 mm.
Length of the smaller valve	49 „	42 „
Entire breadth of the shell	92 „	82 „
Thickness of both valves	45 „	38 „
Apical angle of the larger valve	132°	129°
„ „ „ smaller valve	130°	132°

Locality and geological position.—The species is on the whole very rare in the Salt-range. It occurs in the higher layers of the lower division and at the base of the middle division of the Productus-limestone. There is one locality where the species may be obtained in any numbers,—this is Pail. It occurs there in rusty micaceous sandstones, and fills a whole bed with its shells. This sandstone is situated at the upper limit of the lower division. I was, however, not able to extract more than 16 specimens with the rather small instruments that were at hand. A little quarrying might furnish within a short time hundreds of specimens. There are only two more localities where the species has been detected: one specimen was collected by me at Amb at the base of the compact limestones forming the middle division of the Productus-limestone, and one fragmentary specimen was found by Mr. Wynne at the Verála scarp.

Remarks.—For a very long time I considered this species to be identical with *Spirifer cameratus*, Mort., and I am still convinced that it is very nearly related to that species. The present species differs from *Spir. cameratus* by its far more considerable size and by the absence of the distinct bundling of the radial ribs so characteristic for Morton's species. The only figure with which the Indian shells

absolutely agree, is that published by Mons. Marcou under the name of *Spirifer striatus*. The original of this drawing was found at Pecos village, New Mexico, filling a whole bed of limestone, associated with *Athyris substilita*, Hall, and *Spir. cameratus*, Mort. (*Spir. striatus* var. *triplicatus*, Marcou). The bed from which the specimen was collected therefore very likely forms part of the coal-measures. The determination as *Spirifer striatus* by Mons. Marcou was correct beyond doubt at the time of the publication of Marcou's work, and it has been considered as correct up to the present, but I think the Indian specimens as well as Marcou's drawing exhibit some peculiarities which make a distinction from *Spir. striatus*, Mart., desirable. The most striking peculiarity consists in the median fold, which is higher and sharper, and the sinus correspondingly deeper and narrower, than in Martin's species. Another peculiarity which is very striking is the flatness of the ventral and the great inflation of the dorsal valve. These peculiarities, which cause a very striking boldness of outline, can, I think, well be used for the distinction of a proper species.

Of American lower carboniferous species, *Spir. logani*, Hall, may be compared; but in this form the median fold is much less high and sharp, and the radial ribs are coarser and less numerous.

II.—Group of *SPIRIFER TEGULATUS*, Trautschold.

3. Spirifer Musakheylensis, Davidson: Pl. XLV.

1862. *Spirifera musakheylensis*, Davidson: Quart. Journ. Geol. Soc., Lond., Vol. XVIII, p. 28, pl. II, fig. 2.
1863. *Spirifera musakheylensis* (Dav.), Koninck: Fossiles paléoz. de l'Inde, p. 34, pl. XI, fig. 2.
1866. *Spirifera musakheylensis*, Davidson: Quart. Journ. Geol. Soc., Lond., Vol. XXII, p. 41, pl. II, fig. 5.

The general outline of this species is elongately transverse, with a hinge-line, which is mostly as long as the greatest breadth of the shell, but sometimes also slightly shorter. The valves are generally about equally inflated; sometimes, however, the inflation of the dorsal valve is somewhat greater. The median fold is well developed. The valves are covered with a radial striation which always shows a distinct bundling. These radial striæ are crossed by concentric lamellose striæ of growth.

The ventral valve has in different specimens a very different curvature; always, however, the longitudinal curvature is very much stronger than the transverse one. The area is mostly rather broad, very elongated and strongly reclining; sometimes its margins are nearly paralled to the hinge-line. The triangular fissure is very large, but in none of the specimens at my disposal is the pseudo-deltidium preserved. The beak is thick, short, pointed, and not much bent over. The sinus is more or less broad and deep. It commences always at the very apex of the beak, and is in the beginning sharply limited, but lower down the limiting ridges become more and more indistinct. The radial striation begins at the apex of the beak, as a few strong ribs arranged on both sides of the sinus. There are very generally seven ribs on each side, and three more within the sinus. Each of these ribs very

soon becomes split up into three, and thus gives rise to the formation of a bundle of ribs, in which the ribs are more and more augmented as the bundle approaches the margins of the valve; so long as the bundles are distinguishable there are rarely more than seven ribs within one bundle. The bundling disappears sometimes at an earlier, sometimes at a later, stage of growth; quite full-grown specimens only rarely show the bundling distinctly at the margins of the valve.

The dorsal valve is generally slightly more strongly vaulted than the ventral one, but it appears to be very variable in its general curvature. Longitudinally the curvature is very strong on the lateral parts; on the median fold, however, it is often only slight. In the transverse direction its curve is nearly always inconsiderable. The apex only projects a little above the hinge-line, and the area is generally very narrow in this valve. The median fold mostly projects very strongly, and is sometimes broadly, sometimes narrowly, rounded on the top. It begins at the very apex of the valve as a single rib, and on each side of it there are six more ribs, which are the first indications of the rib-bundles that ornament the valve further down, and of which the radial striation consists. Each bundle is generally composed of six sharp ribs, which are, however, repeatedly augmented by intercalated new ones in large specimens. The median fold bears 14 such ribs on a middle-sized specimen.

The most characteristic feature of the species is the lamellose erect striæ of growth, which in great numbers and closely arranged cover both valves. Besides these there are some irregular, more strongly developed, imbricating marks of growth running parallel to the margins of the valves.

The internal characters of this species are not known to me.

This species varies somewhat with age. In young specimens the radiating bundles of ribs are always very strongly developed, so that the margins of the valves form a strongly bent zigzag line. At the same time the hinge-line is always shorter than the greatest breadth of the shell. In very old specimens, again, the area of the ventral valve becomes more and more broad, and attains often nearly parallel margins.

The species can attain very considerable dimensions, but larger specimens than that figured by Davidson, or the one represented on pl. XLV, fig. 6, have not been observed by me.

The measurements of three specimens, No. I from Morah, No. II from the Chittawán, and No. III from Chidru, are as follow:—

	I.	II.	III.
Entire length of the shell	21 mm.	36 mm.	56 mm.
Length of the smaller valve	19 „	31 „	45 „
Greatest breadth of the shell	30 „	64 „	88 „
Length of the hinge-line	16 „	...	79 „
Thickness of both valves	14 „	25 „	39 „
Apical angle of the larger valve	125°	130°	130°
„ „ „ smaller valve	140°	145°	143°

Locality and geological position.—This species is not rare in the Salt-range, but

it is not very common either. It extends through the whole thickness of the Productus-limestone, but is most numerous in the middle division of it.

It has been found in the lower division by Dr. Oldham at Chidru in black sandstones (two specimens).

In the middle division it has been collected by myself in the section at Khúra (uppermost beds), two specimens; at Virgal in the crinoid beds and in the coral beds (three specimens), at Chidru also in the top beds (one specimen), and at Katta in the very lowest beds (bed No. 12 of my note-book) one specimen. Mr. Wynne has brought the species from Morah (twelve specimens), and from the Chittawán (two specimens); Dr. Oldham found it at Vurcha (one specimen), and Dr. Warth at Musakheyl (two specimens). Trans-Indus I collected the species at Káfirkot (one specimen), and Mr. Wynne at Omarkheyl (one specimen).

In the upper division the species has been found by myself at Chidru (three specimens, one in the Cephalopoda bed), in the Cephalopoda bed at Jabi (six specimens), and west of Khura (two specimens).

Remarks.—As has been remarked already above, the character which makes the distinction of this species most easy consists in the erect lamellose condition of the striæ of growth. Nevertheless the preservation of this character is not always so perfect as could be desired, and it cannot be considered as a specific distinguishing character, if just in *one* specimen this character is not observable. There are many specimens in the collection on which this character is well exhibited only on a very limited part of the shell, whilst on all the other parts it is only very indistinctly visible, though the shell appears to be perfectly well preserved. It seems that in such specimens the characteristic sculpturing was already partly lost before they were imbedded.

Though this character seems to be one which is rather easily destroyed, yet it must be taken heed of, as it enables us to establish a more close comparison between the present and other allied forms. The species which is beyond any doubt most nearly related to the present one is *Spirifer tegulatus*, Trautsch. The peculiar sculpturing, so similar to that of *Spirifer musakheylensis*, has been excellently described and figured by Trautschold; but from his description and figures it can also be concluded with very great certainty that the two species are different. In *Spirifer tegulatus* the radiating ribs are much coarser, and the lamellose sculpturing more strongly developed than in the Indian forms, and there is apparently but little doubt that the two represent different specific types. Nevertheless it is highly probable that the Russian species, which occurs in the upper carboniferous limestone of Moscow, is the ancestor of the Indian shells. Another species which bears such erect lamellose striæ of growth is *Spirifer condor*, Orb., from Yarbichambi in Peru. It has for a long time been considered as a synonym of *Spir. striatus*, or later of *Spir. cameratus*, Mort. It is distinct, however, from the former by the lamellose striæ of growth, and from the latter by these as well as by the nearly entire absence of the bundling of the ribs. From *Spir. musakheylensis* it differs by about the same characters by which it is different from *Spir. cameratus*.

If we set aside the lamellose character of the striæ of growth, then there is quite a number of species to which the present one might be compared. There is a whole group of forms, of which *Spir. fasciger*, Keyserl., is probably the ancestor and must be taken as the prototype. Most authors unite the entire group with *Spir. striatus*, Mart., but it appears probable that several species can be distinguished. Species which most nearly approach *Spir. fasciger* are *Spir. cameratus*, Morton, and *Spir. timorensis*, K. Mart. All these species are characterised by a distinct bundling of the ribs, similar to that occurring in *Spir. musakheylensis*, but the lamellose striæ of growth are constantly absent.

Least nearly related to the species here under consideration are those species belonging to the group of *Spirif. striatus*, Mart., and especially that species itself. The bundling of the ribs is much less distinctly developed in this group, and is mostly restricted to the apical region of both, or only of the ventral valve, and lamellose striæ of growth have never been observed.

There seems to be but very little doubt that all the three groups of form which I have indicated above have taken their origin from *Spir. striatus*, Mart.

4. Spirifer ambiensis, Waagen: n. sp., Pl. XLVIII, fig. 1.

It is with great doubt and hesitation that I venture to introduce a separate name for the form here under consideration, as it is represented only by a single specimen; but as this exhibits a very characteristic form and at the same time occurs in beds different from those in which *Spir. musakheylensis* is to be met with, it seems at least probable that a different species is indicated by that specimen.

The general outline of this species is transverse, semicircular, with very flat valves and a very narrow, nearly linear area, being as long as the greatest breadth of the shell. The valves are covered by a fine radial striation, the striæ being arranged in bundles, and showing in places a slight granulation.

The ventral valve is about as little curved in the longitudinal as in the transverse direction, only in the region of the sinus the curvature is somewhat stronger. The area is extremely narrow, 3·5 millimetres long and only 2 millimetres broad below the apex. The beak is thick, short, pointed, and well bent over; the triangular fissure below it rather broad. A pseudo-deltidium is not present in the specimen which serves for description. The sinus is distinct, but not very deep. It commences at the apex of the beak. On each side of it there are seven bundles of ribs, which, however, disappear almost entirely towards the margin of the valve. Each bundle is generally made up of seven ribs, and within the sinus there are about twenty-four ribs near the margin of the valve. The ribs appear at places slightly granulated, but I can nowhere see the highly elevated lamellar striæ of growth, which characterise the *Spir. musakheylensis*.

The dorsal valve is not more strongly vaulted than the ventral one, and its longitudinal as well as its tranverse curvature is very small. The apex is barely at all prominent, and the area is about half as broad as that of the opposite valve.

The median fold is tolerably prominent and rather broad, but more or less narrowly rounded on the top. It is followed on each side by six to seven bundles of ribs, which become rather indistinct towards the margin of the valve. This valve is so much incrusted by rocky matter, that it becomes difficult to count exactly the number of ribs which compose one bundle. A granulation of the ribs is not observable on this valve.

The internal characters of this species have not been observed by me.

The measurements of the only specimen are as follow:—

Entire length of the shell	33 mm.
Length of the smaller valve	29 „
Entire breadth of the shell at the hinge-line	55 „
Thickness of both valves	20 „
Apical angle of the larger valve	133°
„ „ „ smaller valve	151°

Locality and geological position.—The only specimen of this species that is known to me was found by myself at Amb in the topmost beds of the Productus-limestone.

Remarks.—This species is apparently very nearly related to *Spir. musakheylensis*, Dav., and for a long time I was inclined to consider it only as a variety of that species; but after a careful consideration of all circumstances, I thought it more prudent to distinguish specifically between the two forms. The extreme narrowness of the area and the great flatness of the valves of the Amb specimen are very striking characters, which can well serve for a specific distinction. I cannot say so much of the absence of erect lamellose striæ of growth. Already in the description of *Spir. musakheylensis*, I have pointed out that in some specimens these striæ of growth were absent in such a manner that one must suppose the specimens were partly deprived of them before they became imbedded. It is thus very possible that the species here under consideration also once possessed such striæ of growth, and that these have been destroyed in the only specimen that has come under observation. Nevertheless it cannot be denied that the ribs of this species show for the most part a very remarkable degree of smoothness.

Of the species which have never borne striæ of growth of a similar description, none is closely related to the present one, as all of them have much more inflated valves and a broader area.

Spir. ambiensis thus may well deserve a proper specific designation, so much the more as its geological position is a peculiar one. *Spirifer musakheylensis* extends through the whole Productus-limestone, and is still numerous in the upper division of it, but in the top beds the species is absent and replaced by *Spir. ambiensis*.

III.—Group of *SPIRIFER DUPLICICOSTA*, Phill.

5. Spirifer wynnei, Waagen: n. sp., Pl. XLIV, figs. 6, 7.

The general outline of this species is transversely oval, with a hinge-line shorter than the greatest breadth of the shell. The median fold is very little prominent, though sometimes slightly produced in the frontal part. The area is large and reclining. Both valves are covered with bifurcating ribs.

The ventral valve is deep, much deeper than the dorsal one. It is tolerably, but not very strongly, curved in both directions. The area is very broad, triangular, slightly concave and strongly reclining. The triangular fissure in the middle of it is extremely large. The beak is very prominent, thin, pointed, and but little bent over. The sinus begins at the apex of the beak, but is very shallow, rounded, and not sharply marked off from the remainder of the shell. The radiating ribs are rounded on the top, not very thin and not numerous. There are about ten within the sinus and twenty on each lateral part of this valve.

The dorsal valve is flatter and less deep than the ventral one. Its curve is very small in the longitudinal direction, and is a little impressed not far from the frontal margin. In the transverse direction its curve is somewhat more considerable. The apex is comparatively prominent, but not incurved. The area is tolerably broad in the middle and bears a very large triangular fissure. The median fold is very little prominent, broadly rounded, and in some cases so flat as to be barely distinguishable; it often, however, projects a little in the frontal line. The whole valve is covered by bifurcating radial ribs, the number of which is somewhat variable (50 to 70). These ribs are crossed by very numerous fine striæ of growth.

The internal structure of this species is not known to me. It could only be observed that strong dental plates are present in the ventral valve.

The measurements of a specimen from Bilot are as follow:—

Entire length of the shell	46 mm.
Length of the smaller valve	38 „
Entire breadth of the shell	62 „
Length of the hinge-line	49 „
Thickness of both valves	30 „
Apical angle of the larger valve	105°
„ „ „ smaller valve	136°

Locality and geological position.—This is a very rare species, entirely restricted to the hard compact limestones of the middle division of the Productus-limestone. It has been found by myself at Virgal in the coral beds. Mr. Wynne brought the species from Morah and Trans-Indus from Bilot, where he collected it in a flesh-coloured marble. One specimen was also contained in Dr. Verchere's collection; it is preserved in a dark liver-coloured limestone, but the locality is not known.

Remarks.—The species which appears to be most nearly related to the present

one is *Spir. duplicicosta*, Phill. Nevertheless there is but little doubt that the Indian form is different from Phillips' species. The very small development of the median fold in the Indian shell is one of the most striking differences, another one consists in the broader and more strongly reclining area; these two characters give a very peculiar aspect to the shells here under consideration, and make a distinction from *Spir. duplicicosta* not difficult. The fasciculation of the ribs, which is of so common occurrence in the last-named species, is entirely absent in *Spir. wynnei*.

IV.—*ISOLATED SPECIES.*

6. Spirifer oldhamianus, Waagen: n. sp., Pl. XLVI.

It is a large but very rare species that I have now to describe, and it is in many respects a very characteristic one.

The general outline of this species is transversely oval, with strongly inflated valves, a very short hinge-line, small area, and little prominent beak. The valves are covered by a tolerably fine radial striation.

The ventral valve is very strongly bent in the longitudinal direction, but not so much so transversely. On the whole, it is slightly less deep than the dorsal valve. The beak is thick, short, pointed, and tolerably well bent over. The area is very small, not distinctly marked off from the remainder of the shell, and not occupying the whole dorsal face of the apex of this valve. It is slightly concave. The triangular fissure is tolerably large, but there is no pseudodeltidium visible in the few specimens at my disposal. The sinus is deep, commencing at the apex of the beak, but it is not sharply marked off from the remainder of the shell. The part of the shell corresponding to the sinus is strongly produced in the frontal region. The whole valve is covered by a radial striation which shows a certain tendency to form bundles. The striæ augment by bifurcation, and are very irregular in number in different specimens, the striation thus becoming sometimes rather fine, sometimes less so, even sometimes almost disappearing at certain places. The bundling of the striæ is nearly limited to the apical region of both valves.

The dorsal valve is slightly deeper than the ventral one, and about equally strongly vaulted in both directions. The apex is but little prominent, and the area very narrow. The most striking feature of this valve is the extremely prominent and rather sharp median fold which begins at the apex of the valve, and is highest in the frontal region. It is rather narrow on the whole, though rather variable in this respect. This valve also is covered by a radial striation which shows an indistinct bundling, chiefly in the apical region.

Numerous striæ of growth cover both valves; some of them are more strongly marked and imbricating.

Of the interior characters of this species nothing is known to me.

The measurements of two specimens, No. I from Katwâhi, and No. II probably from near Musakheyl, are as follow :—

	I.	II.
Entire length of the shell	62 mm.	57 mm.
Length of the smaller valve	48 „	46 „
Entire breadth of the shell	80 „	76 „
Length of the area at the hinge-line	40 „	40 „
Thickness of both valves	56 „	45 „
Apical angle of the larger valve	130°	135°
„ „ „ smaller valve	135°	139°

Locality and geological position.—There are only two specimens of this species preserved in the Salt-range collection. One of these was found by myself in the mountains east of Katwâhi, in reddish marble-like silicious limestone; the other was brought from the Salt-range by Dr. Oldham, but the exact locality is not known; it is also preserved in a hard silicious limestone, and comes very probably from the vicinity of Musakheyl. There is no doubt, however, that the second specimen, as well as the first one, comes from the middle division of the Productus-limestone, and that the species seems thus to be restricted to that division as far as our knowledge reaches at present.

Remarks.—This species appears to be more or less nearly related to two groups of *Spirifer*, the group of *Spir. striatus*, Mart., and the group of *Spir. duplicicosta*, Phill., but it agrees exactly with none of them. From *Spir. striatus* and the allied species, the present one is very markedly different by its small area and short hinge-line, which occupies not more than half of the entire breadth of the shell.

A more close relation than *Spir. striatus* may be found in *Spir. duplicicosta* and allied forms, but also here marked differences can be pointed out. One of them consists in the circumstance that the area is not sharply defined in the Indian shell; another, that the ventral valve is less deep than the dorsal one; just the reverse of what is the case in *Spir. duplicicosta*. From *Spir. wynnei*, W., in particular the shell here under consideration differs by its much more inflated valves and smaller area.

On the whole, this species seems to be related to none other so closely that I should be disposed to place it with any of them in one and the same group.

V.—Group of *SPIRIFER TRIANGULARIS*, Mart.

7. Spirifer alatus, Schloth., sp.: Pl. XLVIII, figs. 2 & 7.

1813. *Terebratulites alatus*, Schloth.. Leonh. Min. Taschenb., Vol. VII, p. 58, pl. II, figs. 1-3.
1827. *Spirifer undulatus*, Sow.: Min. Conch., Vol. VI, p. 119, pl. 562, fig. 1.
1845. *Spirifer cordieri*, Robert: Atlas du voyage de la Comm. sc. du Nord, pl. 19, fig. K.
1849. *Spirifer alatus* (Schloth.) Koninck: Nouvelle Notice sur les fossiles de Spitzberg, p. 9. pl. 1, fig. 5.
1850. *Trigonotreta alata* (Schl.), King: Monogr. Brit. Perm. Foss., p. 130, pl. IX, figs. 4-12.
1850. *Trigonotreta undulata* (Sow.), King: *ibid.*, p. 131, pl. IX, figs. 1-3, 13-17.
1858. *Spirifera alata* (Schloth.), Davidson: Monogr. Brit. Perm. Brach., p. 13, pl. I, figs. 23-36; pl. II, figs. 6-7.
1861. *Spirifer alatus* (Schloth.), Geinitz: Dyas, I, p. 87, pl. XVI, figs. 1-7.

This species has already often been excellently described, and I can add but

little from the Indian specimens to elucidate it further. Nevertheless a description of the Indian specimens will be of interest, as it will give occasion to judge more definitely on the exactitude of the determination than would be possible from the figures only.

As in the European specimens so also in the Indian ones the general outline is extremely variable, but in India the transversely fusiform shape seems to prevail, as short forms, like that figured by Koninck (Nouv. not. sur les foss. du Spitzberg) from Milbitz, are very rare in India.

The valves are about equally deep, the ventral one sometimes slightly deeper than the dorsal. The curvature of the ventral valve is very strong in the longitudinal direction, and very small transversely. The beak is prominent, tolerably thin and strongly incurved.

The area is broad, not strongly concave, with sub-parallel margins. It bears mostly a distinct vertical striation. The triangular fissure is tolerably large, but no specimen at hand is sufficiently well preserved to show the pseudo-deltidium. The sinus commences at the apex of the beak, nevertheless it remains always shallow. It is entirely smooth in the beginning, but lower down a median rib appears, which, however, never becomes very high or conspicuous. The sinus is not very broad. The lateral parts of the valve are covered by rounded ribs, separated from each other by rather narrow furrows. There are about twelve on each side of the sinus, the last of them, however, towards the end of the wings becomes very indistinct. The frontal part of the shell is considerably produced in the region of the sinus.

The dorsal valve is generally as strongly vaulted as the opposite one; sometimes, however, it is less deep. Its curve is very strong in the longitudinal direction, but very small transversely. The apex is but little prominent, and the area extremely narrow, nearly linear. The median fold begins at the apex of the valve; it is highly prominent, not sharp, but more or less broadly rounded on the top. On each side of it there are about eight radial ribs distinctly visible. Towards the extremity of the wings the ribs become, however, very indistinct, so that the shell appears either nearly quite smooth, or horizontal ribs are slightly indicated as in the specimens figured by King (Monogr. Brit. Perm. Foss., Pl. IX, figs. 10, 11).

The radial ribs on both valves are mostly simple; in some specimens, however, one or other appears bifid. The whole surface of both valves, except the area, is covered by regular closely arranged, lamellar striæ of growth, which are, however, for the greater part destroyed by weathering on the specimens at my disposal. Nevertheless here and there they are excellently observable on the Indian shells.

The internal characters could not be observed in any of the Indian specimens.

The measurements of a very transverse specimen from Dokri are as follow:—

Entire length of the shell	23 mm.
Length of the smaller valve	17 „
Entire breadth of the shell	62 „
Thickness of both valves	18 „
Apical angle of the larger valve	128
„ „ „ smaller valve	140°

Locality and geological position.—This species is a rather rare one, and appears to be entirely restricted to the lower division of the Productus-limestone. The greatest number of specimens (five) were collected by Mr. Wynne at Dokri in a rusty, somewhat oolitic limestone; two more specimens I found myself in the dark grey and brown argillaceous sandy rock forming the *Chonetes* bed at Amb. In both localities the rocks from which the specimens were obtained form part of the lower division of the Productus-limestone.

Remarks.—There remains, I think, but very little doubt that the specimens described above belong really to Schlotheim's species. I should not be able to indicate any marked difference between the European permian form and the Indian shells. Of European carboniferous species, only *Spir. triangularis*, Mart., and *Spir. convolutus*, Phill., can be compared, and there might perhaps exist some doubt whether the Indian shells ought not to have been considered identical with one of these species. *Spirifer triangularis* is the first to claim consideration. I regret to say that I have not been able to procure a specimen of this species for comparison; the species is so extremely rare in Europe that no specimen was procurable. The English specimens, as far as can be judged from Mr. Davidson's figures, seem to have generally the rib within the sinus much more developed than the Indian shell, and are also generally less strongly transverse, with more attenuated wings. Another difference seems to consist in the beak, which is more prominent, and has a smaller apical angle in the European specimens, and in the absence of smooth parts or horizontal ribs on the wings. By all these characters the Indian specimens differ from European specimens of *Spir. triangularis*, and approach the *Spirifer alatus*, Schl., of the permian period of Europe. I therefore think myself justified in assigning the Indian specimens rather to *Spir. alatus* than to *Spir. triangularis*.

The other species which must be compared is *Spir. convolutus*, Phill. In general outline this species appears very similar to the Indian form, and only after close comparison of the parts of the shell forming the sinus and the median fold does it become evident that the Indian specimens cannot belong to Phillips' species. The median fold is never simple in *Spir. convolutus*, but shows nearly always traces of a combination of several radial plications. The same is the case with the sinus: here also several plications are placed within that part of the shell, only a more conspicuous median fold is always absent. None of these characters can be detected in the Indian shells, and there is thus not the slightest doubt that these specimens cannot be united with *Spir. convolutus*.

There has, however, been described a species from Kashmir,—*Spir. kashmiriensis*,—by Mr. Davidson, with which I should have united without the slightest hesitation the specimens from the Salt-range, had I not detected some differences which prevented my doing so. *Spir. kashmiriensis* agrees nearly perfectly with the Salt-range shells, except in the somewhat finer radial ribbing (which is of no great importance) in the unproduced frontal part of the sinus, and in the absence of lamellar striæ of growth. This latter point appears to me to be of material importance, as just by the presence of these regular lamellar striæ of growth and by the

sporadic occurrence of dichotomous radial ribs the Salt-range specimens approach more closely *Spir. alatus* than any other species. There might perhaps exist an ascending developmental series from *Spir. triangularis* through *Spir. kashmiriensis* to *Spir. alatus*. The *Spir. triangularis* figured by Möller from the upper carboniferous limestone of the Ural shows a great similarity to *Spir. kashmiriensis*.

Thus there seems no escape from the fact that *Spir. alatus*, that characteristic permian species, really occurs in the lower division of the Productus-limestone of the Salt-range.

8. Spirifer niger, Waagen: n. sp., Pl. XLVIII, figs. 4—6.

The general outline of this species is more or less elongately transversely fusiform, with a very prominent median fold and corresponding sinus, in the middle of which a well-developed ridge is placed. The valves are covered by radiating ribs, of which three to four form one bundle, or one thick rib.

The ventral valve is not very strongly vaulted, either in the longitudinal or in the transverse direction. The beak is not very prominent, thin, pointed and well bent over. The area is tolerably broad, slightly concave with sub-parallel margins; the hinge-line occupies the greatest breadth of the shell. The triangular fissure is covered up by rocky matter in all the specimens at my disposal, and it can therefore not be observed whether a pseudo-deltidium is present or not. The sinus is rather deep and broad, and commences very distinctly at the apex of the beak. In the frontal region that part of the shell by which the sinus is formed is strongly produced. The whole valve is covered by radiating ribs, of which five are within the sinus, and of these again the median one is the strongest, and becomes rather highly prominent in the vicinity of the frontal line. On each side of the sinus there are seven thick ribs, each of which is again sub-divided into about four smaller ones, sometimes rather indistinct, but generally well developed. On the extremity of the wings in nearly all specimens horizontal ribs occur extending about parallel to the hinge-line, but in very transverse specimens they are much more distinctly developed than in the less transverse varieties.

The dorsal valve is somewhat more vaulted than the ventral one, its curvature is slightly stronger in the longitudinal than in the transverse direction. The apex is very little prominent, the area very narrow. The median fold is very high and narrowly rounded on the top. It begins on the apex of the valve and increases rapidly in height. On each side of the median fold there are about six to seven thick radial ribs, each of which is sub-divided in three smaller ones. The extremity of the wings is ornamented in this valve also by horizontal ribs.

Both valves, if the surface of the shell is well preserved, bear a very conspicuous concentric sculpturing. It consists of very regular closely arranged, imbricating lamellar striæ of growth, which again are crossed by an extremely fine radial striation, exactly in the manner figured by King (Monogr. Brit. Perm. Foss., Pl. IX, fig. 17) of *Spirifer alatus*, or by Davidson (Carb. Mon., Pl. L., fig. 9) of *Spir. bisulcatus*.

Of the internal characters of this species not much is known to me. The extreme thickening of the shell substance in the apical region of the ventral valve is very remarkable, as can be observed in several broken specimens. The whole space on both sides between the hinge-line the dental plates and the apex of the valve forms one shelly piece, so that the whole area rests on a solid shelly mass. The transverse section of one of the spiral cones is figured in Pl. XLVIII., fig. 6 d. From this it appears probable that the cones were in shape very much like those figured by Davidson of *Spir. alatus*.

The measurements of a specimen from Amb, representing a slightly transverse variety, are as follow:—

Entire length of the shell	23 mm.
Length of the smaller valve	18 „
Entire breadth of the shell	43 „
Thickness of both valves	15 „
Apical angle of the larger valve	123°
„ „ „ smaller valve	143°

Locality and geological position.—This species is extremely numerous in certain beds of the lower division of the Productus-limestone, but it is very difficult to get tolerably well-preserved specimens. The valves are nearly always disunited; a circumstance which is probably due to the difference in structure of the two valves, the ventral one being extremely thick and heavy, while the dorsal one is light and thin. The greatest number of specimens was met with by me in the Chittawán near Ghari, where a whole bed of black, sandy, calcareous rock, forming part of the lowest fossiliferous beds of the Productus-limestone, is literally filled with the valves of this species. The valves are all single, and it is almost impossible to extract tolerably complete specimens from the very hard rock. I brought away about a dozen specimens.

Another locality where the species is not rare is Amb. Here I collected nine specimens in the so-called *Chonetes* bed. Four more specimens were collected by Mr. Wynne at Dokri, together with *Spirifer alatus*, Schloth.

Remarks.—This species is most nearly related to *Spir. alatus*. Schl., with which it has in common the general shape, the prominent rib in the middle of the sinus, and the minute concentric ornamentation. It differs from Schlotheim's species by the finer radial ribbing arranged in bundles and extending over the sinus on both sides of the median rib, and by the more acute apical angle of the ventral valve.

Spir. triangularis, Mart., must next be compared. The differences between this species and *Spir. niger* are about the same as between the latter and *Spir. alatus*, only that the apical angle of the ventral valves of the two first species is less largely different.

With regard to *Spir. convolutus*, it must be stated that the difference is greater than appears at first sight, and if the median rib in the sinus were not present, it would be difficult to distinguish between the two forms. Also in *Spir. convolutus* the ribs are often sub-divided into several smaller ones, the sinus is covered

by several folds and the whole shape is nearly identical. The chief difference of *Spir. niger* from Phillips' species consists in the smooth median fold, which shows no sub-divisions, and in the existence of a prominent fold in the middle of the sinus, by which character the relation of the present species to *Spir. alatus* and *Spir. triangularis* is authenticated.

On the whole, the present species is about intermediate beween *Spir. alatus*, Schloth., and *Spir. convolutus*, Phill., and seems to be a vicarious species for one of these two.

Sub-family: *MARTINIINÆ.*

Genus: MARTINIOPSIS, Waagen, n. gen.

This genus has for a long time greatly puzzled me, and even now I am not quite certain as to its relations. In the beginning I considered the shells belonging to the genus as something like *Merista*, Suess, until I succeeded in exposing the large triangular fissure situated below the apex of the beak, and in cleaning the area of the smaller valve. After this it appeared tolerably certain that we had to deal with a member of the family *Spiriferidæ*. It was not possible for me to expose also the internal characters of the genus, partly on account of the hardness of the sandy limestone in which these fossils are preserved, and partly on account of the scarceness of the specimens. I have, however, suspicions that some kind of a loop exists, and therefore these shells will require in future some closer examination.

As far as the characters can be made out, the genus may be specified in the following manner.

Shell more or less globular or thick lenticular, smooth; area in the ventral valve not distinctly marked off from the remainder of the shell, very small, interrupted in the middle by a tolerably large, triangular, deltidial fissure. Dorsal valve with a narrow but distinctly marked off smooth area. Internally the ventral valve possesses two strongly developed dental plates, which limit the deltidial fissure on both sides and diverge towards the frontal region. They can always be seen through the transparent shell and give it an appearance very much like *Merista*. In the dorsal valve two strong diverging septal plates are present, and support for some distance the crura to which the spirals are fixed. The spirals seem to be very small, but I cannot say anything definite on the matter.

The shell is coated with an epidermis, which exhibits a very distinct punctation, very similar to the punctation of *Terebratula*. The median shell-layers show this punctation much less distinctly, though it can be well observed in places. The punctation is very fine, close, and arranged in quincunx.

By the smoothness of the shell and the general appearance the forms belonging to this genus appear to be very closely related to *Martinia*, and I was for a long time inclined to place these shells in that genus; but after a careful study of typical specimens of *Martinia glabra* from Visé, which I owe to the kindness of Mons. de

Koninck, I found that these shells were devoid of dental as well as of septal plates, and were therefore distinct generically from the Indian fossils.

Of other genera the genus *Mentzelia*, Quenst., appears to be most nearly related, but is distinct from the present genus by the large development of a median septum in the ventral valve, and by the reduced size of the dental plates.

The genus *Martiniopsis* seems to appear already in the devonian period. There has at least been figured by Quenstedt, under the name of *Spir. lævigatus eifelianus*, a shell from the devonian strata of the Eifel, which according to the development of its internal partitions could very well be considered as belonging to the present genus. Otherwise few are known to me that could be assigned to it. Only in Australia the genus appears to have attained a somewhat more extensive development. It seems at least probable that species like *Spir. darwinii*, *Spir. oviformis*, and the large form figured by Mons. de Koninck under the name of *Spir. glaber* belong to the present genus.

In the Salt-range the genus is rather rare, and is represented by two species, both among the rarest shells in the palæozoic deposits of that country. One of them, which will bear the name of *Martiniopsis subpentagonalis*, W., occurs in the lower division of the Productus-limestone; the other, for which I introduce the name of *Martiniopsis inflata*, W., is restricted to the upper division of the same formation. There has up to the present been discovered no connecting link between these two; and the middle division of the Productus-limestone seems to be devoid of a representative of the genus.

1. Martiniopsis inflata, Waagen: n. gen. et sp., Pl. XLI, figs. 7, 8.

The general outline of this species is more or less transversely oval, with rather strongly inflated valves, smooth shell and small little-prominent beak, without distinctly marked area.

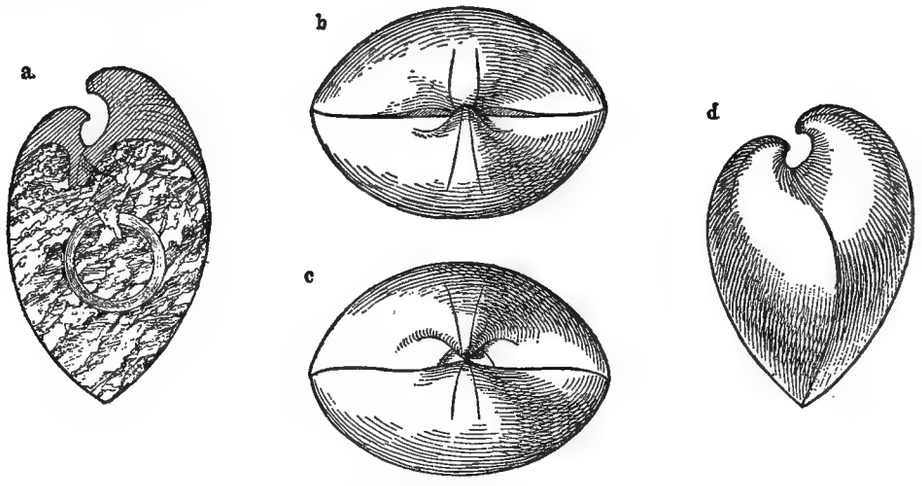


Fig. 9. Martiniopsis inflata, Waagen: n. gen. et sp. Two specimens from the upper Productus-limestone of Chidru. a, longitudinal section, showing the partition walls in the ventral as well as in the dorsal valve, and the spiral; b, view of the beak, the ventral valve below, showing the sharply defined area of the dorsal valve; c, view of the beak, the ventral valve above, showing the deltidial fissure; d, lateral view.

The ventral valve is very regularly curved in the transverse direction, but less so longitudinally. In the latter direction the greatest curve is in the vicinity of the beak, lower down towards the front the valve is somewhat flattened. A sinus does not exist, though the front-line is slightly elevated in the middle. The beak is thin, pointed, but little prominent. It is very strongly bent over, nearly touching the apex of the smaller valve. It is perfectly rounded on its dorsal side, and the area is not marked off by the slightest trace of a ridge. Below the beak there is a rather large triangular fissure, but it could not be stated whether a pseudo-deltidium is present or not.

The dorsal valve is about equally vaulted as the ventral one, but its curve is more regular in both directions. No median fold can be distinguished. The apex is but little prominent, slightly incurved, and provided below with a narrow but distinctly and sharply defined area.

The very strongly developed dental plates are easily visible in nearly all the specimens at my disposal. Less easily can the septal plates in the dorsal valve be distinguished, though these also are generally traceable. In the apical region of both valves the substance of the shell is mostly thickened in a remarkable manner, so that the spaces between the two dental plates, and between the latter and the outer walls of the shell, are to a great extent filled up by shelly matter. In the dorsal valve this thickening takes place to a less extent than in the ventral one.

The punctation of the shell is only very indistinctly visible in this species, as the epidermoidal layer of the shell is always destroyed.

The measurements of two specimens from Chidru are as follow :—

	I.	II.
Entire length of the shell	47 mm.	43 mm.
Length of the smaller valve	41 „	39 „
Entire breadth of the shell	47 „	47 „
Length of the hinge-line	28 „	22 „
Thickness of both valves	30 „	29 „
Apical angle of the large valve	105°	112°
„ „ „ smaller valve	122°	128°

Locality and geological position.—This species only occurs in a single locality, at Chidru, where it has been found by me as well by Dr. Oldham, in the upper division of the Productus-limestone, in yellow sandy calcareous beds. Six specimens have been detected up to the present.

Remarks.—The species here under consideration has an extremely close resemblance to *Mart. oblata*, Sow., and is distinct from that species in external shape almost only by the smaller area and more strongly incurved beak. It has not been stated by any describer whether that species possessed dental plates or not. It is therefore very difficult to compare it more closely with *Martiniopsis inflata*. As, however, *Mart. oblata* is considered by Davidson and others as identical with *Mart. glabra*, and as I am able to state from typical specimens of this species that it possessed no dental plates, there cannot remain much doubt that our *Martiniopsis inflata* is different from *Martinia glabra* as well as from *Martinia oblata*.

2. MARTINIOPSIS SUBPENTAGONALIS, Waagen: n. gen. et sp., Pl. XLII, figs. 9, 10; Pl. XLIII, fig. 1.

The general outline of this species is somewhat elongately oval or subpentagonal, with but little inflated valves, a small and rather indistinct area and prominent beak.

The ventral valve is very equally curved in both directions. The beak is strongly prominent, much bent over and very pointed. On its dorsal side below the apex there is a not very large triangular fissure. The area is somewhat more distinct than in the preceding species, but the ridges marking off the area on both sides are always very low and rounded, though they already approach in their development certain specimens of *Mart. glabra*. A distinct sinus is not developed, though the valve is somewhat produced in the frontal region and thus causes the front-line to ascend slightly. In some specimens a slight impression, replacing the sinus, is observable in the frontal region.

The dorsal valve is about as strongly vaulted as the ventral one, and its curve is very regular in both directions. The apex is very little prominent, and is provided below with a narrow but sharply defined area. A median fold is barely developed; only in some specimens a slight trace of it can be observed in the frontal region.

The internal partitions are very strongly developed in this species. The dental plates extend for more than a third of the entire length of the shell, and the septal plates occupy nearly half the length of the dorsal valve. This can be seen in nearly every specimen from the outside, as the shell is generally transparent. The great thickening of the shell in the apical region of both valves, as observed in the preceding species, is entirely absent in this one. Of the remaining internal characters nothing is known to me.



Fig. 10. Surface sculpturing of MARTINIOPSIS SUBPENTAGONALIS, not far from the beak, strongly enlarged.

The punctation of the shell is very characteristic in this species; it is excellently preserved in several of the specimens at my disposal, but is only quite distinct on the epidermoidal layer of the shell. Where this epidermis has been destroyed the punctation is more or less absent. It consists of very closely arranged fine grooves, which appear as if made with the point of a pin; they are sometimes quite round, sometimes a little elongated. They are mostly placed somewhat irregularly in quincunx. The punctation can still be traced on the layer of the shell immediately below the epidermis; even on the deeper shell-layers I can sometimes

see traces of it, but they are very indistinct. This punctation is crossed by very fine concentric striæ of growth.

The measurements of two specimens from Amb are as follow:—

	I.	II.
Entire length of the shell	32 mm.	30 mm.
Length of the smaller valve	27 „	25 „
Entire breadth of the shell	32 „	35 „
Length of the hinge-line	10 „	15 „
Thickness of both valves	18 „	17 „
Apical angle of the larger valve	82°	100°
„ „ „ smaller valve	128°	137°

Locality and geological position.—Though this species is everywhere rare, yet it occurs at quite a number of localities, and seems to be a species characteristic for the lower division of the Productus-limestone. The greatest number of specimens (three) was collected by myself at Amb in the so-called *Chonetes* bed. One specimen I found in the Chittawán in the lower fossiliferous beds of the Productus-limestone, and another specimen in the Nilawán below Bhál in the grey sandstones (bed No. 0 in the section of my note-book) containing the easternmost representatives of the palæozoic fauna of the Salt-range. One specimen I collected at Pail in beds a little above that with *Spirifer marcoui*, W. Mr. Wynne brought the species from Bilot (Trans-Indus), where he found it in a brown, sandy, calcareous rock, containing many crinoid fragments.

Remarks.—This species is very nearly related to the preceding one, yet the two forms are not difficult to distinguish. The species here under consideration has much flatter valves, a more prominent beak, and a more distinct area than *Martiniopsis inflata*, and is by these characters well distinguishable.

By the more distinctly defined area *Martiniopsis subpentagonalis* approaches more closely to *Martinia glabra* than the preceding species. Nevertheless here also a distinction is very easy, as the septa which exist in both valves of the Indian species are absent in *Martinia glabra*.

Genus: MARTINIA, M'Coy.

Most writers on fossil Brachiopoda have considered M'Coy's genus *Martinia* as only a sub-genus of *Spirifer*, or even have entirely rejected it. It cannot be denied that the characteristic of the genus given by M'Coy is very insufficient, and even for the greater part erroneous, and that this can be considered a sufficient reason for the rejection of the genus. But after the name has been given, and the typical species for which the name has been employed can be found out, it will have to be made use of if we can state that the typical species really possesses characters deserving of a distinct generic designation, though these characters may not have been known to the author who created the name.

Such is the case with *Spirifer glaber* and all the allied forms, among which is

also *Spir. decorus*, Phill., which has been mentioned by M'Coy as the first species of his genus *Martinia*. It is not the smallness of the spiral coils, as has been shown by Mr. Davidson, which may establish a generic distinction between these forms and the true *Spirifers*, but other characters which were not observed by M'Coy. These characters consist chiefly in the absence of dental plates in the ventral valve, which are present in all the true *Spirifers*, but absent in the forms here under consideration. Another character is the punctation of the shell under certain conditions: when the shell of *Spirifer glaber* or the allied forms is perfectly well preserved it is coated all over with a very thin epidermis bearing innumerable fine punctures, which give to the surface of the shell under a strongly magnifying lens an appearance very much resembling that of "chagrin" leather. This epidermis, however, appears to be very easily destroyable, and therefore it can only rarely be observed. The accompanying woodcut represents these punctures in a specimen from Visé which has been kindly communicated to me by Mons. de Koninck.



Fig. 11. Surface sculpturing of MARTINIA GLABRA, Mart., from near the margin of a specimen from Visé, strongly enlarged.

This punctured epidermis seems to be far more easily destroyed on the true *Martinia* than on *Martiniopsis*, in which it may be much better and more frequently observed.

These characters together—the absence of dental plates and the existence of a punctured surface—are, it appears to me, sufficient to constitute the forms bearing them as a proper genus, for which the name *Martinia* will have be to employed. By the absence of dental plates this genus approaches more closely the genus *Reticularia* than any other genus of the family *Spiriferidæ*.

The genus seems to be chiefly represented in the carboniferous deposits of Europe. In America it seems not to be common, and in India it is also very rare. In the Salt-range there can be distinguished about five species, each of which is very rare. It is true that by many palæontologists these species will barely be considered even as varieties only of *Spir. glaber*, but as little can it be denied that the typical shape of *Spir. glaber* is barely represented among the Indian forms. If, then, I were to put down the Indian shell simply as *Mart. glabra*, it would give a very incorrect idea of what really occurs in the Salt-range. On these grounds, and from the considerations which I have already set forth in the introduction to the family *Terebratulidæ*, I prefer to distinguish specifically between these forms.

The five species which I can distinguish among the specimens in the Salt-range collection are for the most part distinct from the European forms. Only one speci-

men I can assign to *Mart. cf. glabra;* it is from the lower division of the Productus-limestone. The others belong to a series of forms distinct from that of the typical *Martinia glabra* by a much shorter hinge-line which terminates on both sides in little wings, and by the circumstance that the sinus of the ventral valve is entirely limited to the frontal region. To this series three species belong: *Martinia warthi*, W., and *Mart. elongata*, W., from the middle division of the Productus-limestone; and *Martinia chidruensis*, W., from the upper division of the same formation. *Mart. warthi* and *chidruensis* are probably in developmental connection. A third series of forms, again, is indicated by a single species which in its general shape shows much resemblance to *Ambocochia planoconvexa*, Shum., but exhibits no trace of the characteristic shell-structure of *Ambocochia*. I therefore must consider this shell as belonging to *Martinia* and as indicating a separate series of forms which perhaps might be brought into connection with *Martinia corculum*, Kutorga. It occurs in the middle division of the Productus-limestone.

According to these considerations we can arrange the species of *Martinia* occurring in the Salt-range in the following manner:—

I.—Group of MARTINIA GLABRA, Mart. sp.
1. *Martinia cf. glabra*, Mart.

II.—Group of MARTINIA WARTHI, W.
2. *Martinia warthi*, Waagen, n. sp.
3. „ *elongata*, Waagen, n. sp.
4. „ *chidruensis*, Waagen n. sp.

III.—Group of MARTINIA CORCULUM, Kutorga.
5. *Martinia semiplana*, Waagen, n. sp.

Of all these species only one (*Mart. cf. glabra*) occurs also in Europe, but its identification with the European species cannot be made quite sure of, as only a single specimen exists, and thus the determination is not of much geological value. Of the other species one or the other might occur also in Europe, but I have not sufficiently extensive material of European carboniferous fossils to state anything in this direction. So much is certain that neither among the specimens figured by Davidson, Koninck and others, nor among the materials which I have for comparison, is there a specimen which can be directly identified with any of the Indian species.

All the species occur in rather sporadic and isolated specimens, thus clearly indicating that they are either stragglers from a territory where the genus is far more plentifully developed, or that they are the last representatives of a group of forms which is on the verge of becoming extinct, and which had been more copiously developed in a former period.

I.—Group of *MARTINIA GLABRA*, Mart. sp.

1.—Martinia *cf.* glabra, Martin, sp.: Pl. XLIII, fig. 9.

1809. *Conchyliolithus Anomites glaber*, Martin: Petrif. Derbiens., p. 11, pl. 43, figs. 9—10.
1821. *Spirifer glaber* (Mart.), Sow.: Min. Conch., Vol. III, p 123, pl. 269, figs. 1, 2.
1836. *Spirifera glabra* (Mart.), Phillips: Geol. of Yorksh., Vol. II, p. 219, pl. 10, figs. 10, 11, 12.
1843. *Spirifer glaber* (Mart.), Koninck: Descr. des anim. foss., p. 267, pl. 18, fig. 1.
1844. *Martinia glabra* (Mart.), M'Coy: Synops. Carb. foss. of Irel., p. 139.
1859. *Spirifera glabra* (Mart.), Davidson: Mon. Brit. Carb. Brach., p. 59, pl. XI, figs. 1—9; pl. XII, 1—3.
1873. *Spirifer glabra* (Mart.), Koninck: Foss. Carb. de Bleiberg, p. 57, pl. II, fig. 12.
1880. *Spirifera glabra* (Mart.), Davidson: Suppl. Brit. Carb. Brach., p. 274, pl. XXXII, figs. 3—5.

As there exists only one specimen, and that not even quite complete, in the Salt-range collection, it is rather difficult for me to give an exact description. Yet I shall try to describe the shell as exactly as possible, in order that others may be able to judge of the determination.

The general outline of the shell is transversely oval with moderately inflated valves and a not very broad sinus and median fold.

The ventral valve is very regularly curved in both directions, and apparently slightly deeper than the dorsal one. The beak has been broken off. The hinge-line is not very much shorter than the greatest breadth of the shell. The sinus is not very broad but well marked; it does not, however, extend to the beak. The shell is somewhat produced in the frontal region. The lateral parts of the valve are entirely smooth, and not a trace of radial ribs is observable.

The dorsal valve is also very regularly curved in both directions, but appears to be slightly flatter than the ventral one. The apex of the valve is broken off. The median fold is well developed, flattened on the top, and there is a slight trace of an impression in the middle of it. The fold reaches up to not far from the apex. The lateral parts of the valve are not very strongly depressed and entirely smooth.

The surface of the shell has everywhere been destroyed, and therefore the punctation can nowhere be distinctly observed. Both valves are, however, covered with closely arranged very fine concentric striæ of growth.

The measurements as far as they can be observed are as follow:—

Entire length of the shell, about	7 mm.
Entire breath of the shell	18·5 „
Length of the hinge-line	13 „
Thickness of both valves	10·5 „
Apical angle of the larger valve, about	112°
„ „ „ smaller valve about	120°

Locality and geological position.—The only specimens of this species that is preserved in the Salt-range collection was found by myself at Amb in dark coaly sandstones, forming, at the base of the Productus-limestone formation, the last fossiliferous bed above the lavender-clays.

Remarks.—I think I cannot be very wrong in assigning the specimen here under description to Martin's species, as in all essential points, chiefly in the comparative length of the hinge-line, the specimen perfectly agrees with *Martinia glabra*. The only point of difference which might possibly be adduced consists in the sinus of the ventral valve, which in typical specimens of *Martinia glabra* extends nearly to the end of the beak, whilst in the Indian specimen it disappears already about half way up from the frontal line. This peculiarity, if it could be stated of a number of specimens, would perhaps be sufficient for the distinction of a proper species, but in this case, being observed only on a single specimen, it seems not to be of sufficient importance for a specific distinction.

II.—Group of *MARTINIA WARTHI*, Waagen.

2.—Martinia elongata, Waagen: n. sp., Pl. XLIII, figs. 5 & 7.

It iswith much hesitation that I introduce this name, as the materials upon which the species is founded are very scanty indeed. But as I do not wish to create such an encumbrance as a "sp. ind." I prefer to give a name under which the form can be quoted.

The general outline of this shell is slightly elongated or as long as it is broad; at the same time it is rather distinctly pentagonal. Sinus and median fold are broad and flat, the hinge-line comparatively long. The valves are but little inflated.

The ventral valve is very regularly curved in both directions. The beak is but little prominent, small and thin, and not much bent over. The area is very small, triangular and concave, and is limited on both sides by prominent obtuse ridges, which form little wings at both ends of the hinge-line. The sinus is very broad and flat, barely at all sunk in, and entirely limited to the frontal region. The frontal part of the valve is considerably produced, so as to cause the frontal line to ascend. On both sides of the sinus two rounded folds are placed, which are again followed by slight impressions. This causes the lateral margins of the valve to form a kind of indistinct zig-zag line.

The dorsal valve is equally curved as the ventral one, and its bend is very regular in both directions. The apex is very little prominent, with a very narrow area. At both ends of the hinge-line little wings are developed. The median fold is very broad, low, and strongly flattened in the middle. It is limited on both sides by rather broad flat furrows or impressions, which are again followed by a kind of fold or rib. The median fold as well as the two lateral ones are limited to the marginal parts of the valve.

The surface of the shell has everywhere been destroyed, and therefore nothing of the punctation is preserved. Numerous faint concentric striæ of growth are, however, well observable.

Of the interior characters of this species nothing is known to me.

The measurements of a specimen from Musakheyl are as follow :—

Entire length of the shell	11·5 mm.
Length of the smaller valve	10 „
Entire breadth of the shell	11 „
Length of the hinge-line	4 „
Thickness of both valves	7 „
Apical angle of the larger valve	90°
„ „ „ smaller valve	102°

Locality and geological position.—The only well-preserved specimen of this species that has served for description was collected by Dr. Warth in the vicinity of Musakheyl in a reddish marble, evidently in the middle division of the Productus-limestone. Two ventral valves were found by myself at Khura in the upper region of the middle Productus-limestone.

Remarks.—This species, though rather nearly related to *Martinia glabra*, can easily be distinguished from that species by its elongated general outline and its characteristically developed short hinge-line, which terminates at both ends in little wings. Of other species, chiefly the two following must be compared. The form here under consideration can be distinguished from those two by its elongated form, low, broad, and strongly flattened median fold, and a comparatively longer hinge-line.

3.—Martinia warthi, Waagen: n. sp., Pl. XLIII, figs. 2 & 8.

The general outline of this species is transversely oval with a moderately prominent beak, very small area and a flattened median fold.

The ventral valve is rather strongly inflated, deep, and about equally curved in both directions. The beak is thick, somewhat prominent, little bent over and very pointed. It bears on its dorsal side an extremely small triangular area, the greatest part of which is occupied by a very large triangular fissure so that the area is reduced to two narrow flattened strips on both sides of it. The immediate margins of the fissure are formed by very narrow sharp ridges, separated from the area by a deep furrow. I could observe no pseudo-deltidium. The area is somewhat prominent and separated from the remainder of the valve by a flatly rounded furrow, which causes the terminations of the hinge-line to form little wing-like prominences. The sinus is broad and flat, but distinctly impressed. It reaches up about half way from the front line, and the part of the valve which corresponds to it is considerably produced in the frontal region. On both sides of the sinus follow low rounded folds, which again are followed by a slight depression, so that the lateral margins of the valve undulate.

The dorsal valve is considerably flatter and less deep than the ventral one. Transversely it is rather strongly vaulted, but longitudinally it is only vaulted in the apical region and flattened or even slightly impressed towards the frontal line. The apex is little prominent, strongly pointed and barely bent over. There is almost no area. The whole internal side of the apex is nearly occupied by a very large

triangular fissure, on both sides of which slight traces of an area are observable. Also in this valve the area is marked off from the remainder of the shell by a shallow furrow, whereby little wings are produced. The median fold is broad, tolerably prominent and rather much flattened on the top. In some specimens a slight impression is observable in the middle as in the true *Martinia glabra*. The fold extends to not far from the apex. It is limited on both sides by broad deep impressions, which are followed by broad rounded folds, in consequence of which this valve appears distinctly tripartite.

The surface of the shell is only in one specimen sufficiently well preserved to show partly the punctation. It consists of numerous thickly strewn granules or impressions which are arranged in irregular radial rows. Besides these the shell is covered with numerous very fine concentric striæ of growth, which are sometimes imbricating.

Of the internal characters of this species nothing is known to me.

The measurements of a specimen from Musakheyl are as follow :—

Entire length of the shell	20·5 mm.
Length of the smaller valve	18 „
Entire breadth of the shell	25·5 „
Length of the hinge-line	8 „
Thickness of both valves	14 „
Apical angle of the larger valve	110°
„ „ „ smaller valve	125°

Locality and geological position.—There are altogether only three specimens of this species known to me. The best preserved of them was collected by Dr. Warth at Musakheyl in the middle division of the Productus-limestone. The specimen is silicified. Another specimen was found by Dr. Oldham at Swás in yellow limestones belonging to the same division, and the last specimen I detected myself in the mountains east of Katwáhi in yellow limestones among the rocks of the lower region of the middle Productus-limestone. The species seems thus to be restricted to the middle division of that formation.

Remarks.—This species, though in external form extremely similar to the strongly plicated varieties of *Martinia glabra* as they have been figured in Davidson's Monograph, Pl. XII, figs. 1, 2, can yet very easily be distinguished from these forms by the extreme shortness of its hinge-line, which terminates at both ends in little wings. This character, so far as I am aware, never occurs in *Martinia glabra*, and has never been mentioned by any of the many describers of that species.

Of other species the preceding one must be compared. *Martinia elongata* differs from the species here under consideration by its elongated shape, much less strongly developed and broader median fold, and a comparatively slightly longer hinge-line.

4. MARTINIA CHIDRUENSIS, Waagen, n. sp., Pl. XLIII, fig. 3.

The general outline is indistinctly rhomboidal or quadratic, with very strongly plicated valves. The area is very small, the hinge-line extremely short.

The ventral valve is very strongly inflated and strongly vaulted in the longitudinal as well as the transverse direction. The beak is thick, strongly prominent, considerably bent over and finely pointed. The area is concave, very small, and bears in the middle a large triangular fissure, which occupies the greater part of the extent of the area. The latter is marked off from the remainder of the shell by a distinct prominent fold which terminates in a little wing at the end of the hinge-line. The sinus is strongly excavated and extends from the front line over two-thirds of the entire length of the valve. It is limited on both sides by strongly prominent folds which are, in the vicinity of the margin, distinctly flattened or even slightly excavated on top. They are followed on each side by a broad impression, after which on each side again a broad rounded fold obtains, so that this valve altogether shows four rather prominent rounded folds, between which three deep impressions are observable. In the frontal region that part of the shell which corresponds to the sinus is much produced, so that the frontal line ascends very strongly in the middle.

The dorsal valve is a little less vaulted and slightly less deep than the ventral one. Its curvature is considerably greater in the transverse than in the longitudinal direction. The apex is very little prominent, pointed and slightly bent over. The area is extremely small and narrow, and occupied nearly for its whole extent by a very broad triangular fissure. Laterally the area is marked off from the remainder of the shell by a slightly prominent little fold, which terminates in a small wing at both ends of the hinge-line. The median fold is narrow and very prominent in the frontal region, but half way up from the front line it becomes rather low, though it extends to not far from the apex. It is not flattened, but narrowly rounded on top. It is limited on both sides by deep rounded depressions, which are followed again by broad rounded folds.

The punctation is nowhere visible. The shell is sparingly covered by very fine, hardly discernible concentric striæ of growth.

The internal characters of this species are not known to me, but on account of the thinness of the shell it can in this as well as in all the species of *Martinia* easily be seen that no dental nor septal plates were present.

The measurements of a specimen from Chidru are as follow :—

Entire length of the shell	24·5 mm.
Length of the smaller valve	20 „
Entire breadth of the shell	27 „
Length of the hinge-line	7 „
Thickness of both valves	17·5 „
Apical angle of the larger valve	102°
„ „ „ smaller valve	115°

Locality and geological position.—There is only one specimen of this species

known to me; it was collected by myself at Chidru in the Cephalopoda beds of the upper division of the Productus-limestone, where it occurred with *Xenodiscus carbonarius*, W., &c.

Remarks.—Though very nearly related to the preceding species, yet the present one can readily be distinguished. The chief differences consist in the median fold being much higher and narrowly rounded not flattened on top, in the beak being more prominent and more strongly incurved, and in the still shorter hinge-line, which occupies barely more than one-fourth of the entire breadth of the shell, characters which all occur in *Mart. chidruensis*, whilst they are absent in *Mart. warthi*.

As all the preceding species so also this one shows a certain similarity to *Martinia glabra*, but like them it is distinguishable from that species by the extreme shortness of the hinge-line.

Martinia warthi and *Mart. chidruensis* occur in successive strata, the one in the middle the other in the upper division of the Productus-limestone, and there can be but little doubt that the two are in developmental connection, the second having taken its origin from the first.

Martinia chidruensis is the geologically youngest representative of the genus *Martinia* known up to the present.

III.—Group of *MARTINIA CORCULUM*, Kutorga.

5. Martinia semiplana, Waagen: n. sp., Pl. XLIII, fig. 4.

The general outline of this species is sub-pentagonal, slightly broader than long, with an inflated ventral and a flat dorsal valve, and a very prominent beak.

The ventral valve is rather strongly inflated, with an equally strong curve in the longitudinal and transverse directions. The beak is thick, very strongly prominent, well incurved and not much pointed. The area is small, concave, and well marked off from the remainder of the shell by a narrow sharp ridge. There is, however, almost nothing left of the area, as by far the greater part of it is occupied by a large triangular fissure. Of sinus there is scarcely any in the proper sense of the word, as only in the frontal part of the valve there is a barely perceptible impression, which can only euphemistically be termed a sinus. Nevertheless the front-line ascends in a tolerably elevated curve, which is, however, solely caused by the circumstance that the valve is well produced in the frontal region. In the place of a sinus there extends from the apex of the beak to the front line a narrowly excavated line, to which, however, no impression corresponds on the median fold of the opposite valve.

The dorsal valve is much flatter than the ventral one. This flatness is chiefly observable in a lateral view of the shell, as the curve of this valve in the longitudinal direction is very little, whilst it is much more considerable in the transverse direction. The apex is little prominent and bears a narrow area, which is clearly

defined from the remainder of the shell by very sharp high ridges. It is cut out in the middle by a large triangular fissure. The median fold is very little developed, and extends only as a broadly rounded crest from the apex to the front, from which on both sides the valve flatly slopes down in a roof-like manner.

The punctation of the shell can nowhere be seen, but in places a fine radial striation can be observed, which is, however, not so close as is indicated on the figure (Pl. XLIII, figure 4*e*). This radial striation is crossed by very numerous fine concentric striæ of growth.

Of the internal characters of this species nothing has been observed. The substance of the shell is rather solid in comparison with *Mart. glabra*.

The measurements of a specimen from Morah are as follow:—

Entire length of the shell	14	mm.
Length of the smaller valve	11	„
Entire breadth of the shell	15	„
Length of the hinge-line	5	„
Thickness of both valves	8·5	„
Apical angle of the larger valve	79°	
„ „ „ smaller valve	118°	

Locality and geological position.—There is only a single specimen of this species preserved in the Salt-range collection; it was found by Mr. Wynne at Morah in the hard white limestones composing the middle division of the Productus-limestone.

Remarks.—This species is easily distinguishable from those previously described by its very prominent beak, flattened dorsal valve and median furrow on the ventral valve.

The similarity of the present species to *Martinia corculum*, Kutorga, is remarkable. The latter form is the prototype of a group of shells which is indicated already in the British carboniferous limestone by forms like those figured in Pl. XII, figs. 9 and 10 in Davidson's Monograph, and considered doubtfully by that author as varieties of *Martinia glabra*. *Martinia corculum* has also been identified with *Mart. glabra* by de Koninck and Möller, but I think this should not be done; if identification is carried so far, the limits of the genus *Martinia* and of the species *glabra* fall together, and the characters of the genus become those of the species. *Martinia corculum*, Kut., and allied species, as *Mart. conularis*, Gmen., form a well-definable group characterised by the very unequal depth of the two valves, of which the smaller one is always the flatter. This group seems to be chiefly represented in the upper carboniferous limestone of Russia. From the species of this group the one now under consideration is distinguishable by its less strongly incurved beak and by its quite indistinctly developed sinus.

Sub-family: *RETICULARIINÆ.*

Genus: RETICÜLARIA, M'Coy.

In accordance with Mr. Davidson's indications I retain the above name in the first line for those forms which have been generally mentioned under the name of *Spirifer lineatus*, Mart. Mr. Davidson founds the generic distinction of these forms from *Spirifer* proper chiefly on the external sculpturing, which is indeed very characteristic and can serve excellently for such a purpose, but it is at the same time combined with very peculiar internal characters which make the distinction of this genus very easy.

The genus may be characterised in the following manner. The general outline of the shells belonging to it is rounded, orbicular or elongately or transversely oval. The hinge-line is always shorter than the greatest breadth of the shell. The area is either distinctly marked off or not. The surface of the shell is covered by fine hair-like spines arranged in concentric rows, and representing double tubes like a double-barrelled gun. These tubes are the entrances of canals, which pass a short distance below the surface layer of the shell, but do not apparently pierce the entire shell-substance. The latter is distinctly fibrous.

Internally the ventral valve is without any partitions; neither dental plates nor a median septum is present. The muscular impressions are situated in an elongately oval groove. In the dorsal valve also not a trace of any partitions can be found: no septum nor shelly support of the dental sockets have been observed by me. A hinge-plate does not exist. The crura are fixed with a broad base to the inner side of the dental sockets and extend straight down approaching each other more and more as they approach the frontal region, then they suddenly bend up to form the first volution of the spiral. They give off no lateral branch whatever. The apex of the spiral is directed sometimes towards the lateral part of the shell, sometimes towards the hinge-line. The muscular impressions of the dorsal valve were not visible in any of the specimens accessible to my observation.

While it seems so easy to make out these characters from specimens collected at Visé as well as from those from the Salt-range, yet I am not quite certain with regard to the British specimens. In his description of *Ret. lineata*, Davidson says nothing as to its internal characters; and also in the Supplement, where the spirals are described, no mention is made of internal partitions, dental plates, &c. In M'Coy's British Palæozoic Fossils, on the contrary, I find the following passage regarding *Ret. lineata*: "This species, from the peculiar structure of the surface, and the slight divergence of the dental lamellæ, with their strong mesial septum, was originally combined in my synopsis with *Sp. imbricata*, *S. reticulata*, *Sp. microgemma*, &c., into a little group called *Reticularia*." Now, it does not seem to me probable that the British specimens of *Reticularia* possess an internal structure different from that of the specimens from Visé with which the Indian specimens entirely agree. It seems far more probable that there has occurred a mingling of

different things by M'Coy, and that he described the above characters from a specimen of *Martiniopsis* or something like it. Nevertheless it would be very desirable to learn more particularly about these British fossils.

A question which is more difficult to solve than the one regarding the generic characters is the distinction of species within the genus *Reticularia*. Mr. Davidson in his most recent publication distinguishes two species among the forms that occur in the carboniferous formation; these are *Ret. lineata*, Mart., and *Ret. imbricata*, Sow. The distinction of these two species rests, however, more with their internal than with their external characters, as in the one the apex of the spirals is directed towards the lateral parts of the shell, and in the other towards the hinge-line. Externally their distinction is very difficult, and until the internal characters became known Mr. Davidson considered the two as identical. The discovery of internal differences in these two forms is, however, of great systematic importance. It shows that the external characters in this genus must be examined with very great care, lest we should unite under one specific name shells which are in reality very different from each other, although their external characters show only slight differences.

After long deliberation and much painstaking I have succeeded in distinguishing three species among the materials from the Salt-range There is first the true *Reticularia lineata* represented among them. This species is, however, not identical with what has been described by Davidson from the Salt-range under that name; this latter represents a different species. The true *Ret. lineata* is very rare in the Salt-range and is there entirely restricted to the lower division of the Productus-limestone. For the form described by Mr. Davidson under the name of *Ret. lineata* I shall introduce the name *Reticularia indica*, Waagen. This species, as far as is known up to the present, seems to be restricted to the middle division of the Productus-limestone. With this species a third one occurs, which will bear the name of *Ret. elegantula*, Waagen. In the upper division of the Productus-limestone the genus is very sparingly represented. A single fragmentary ventral valve was found by Mr. Wynne which allows of no exact determination, and will be classed in a provisional way with *Ret. indica*.

Though I took great pains, yet I could not arrive at a satisfactory grouping of the species of *Reticularia*. It seems on a first glance as if two groups were distinguishable for which *Ret. lineata* and *Ret. imbricata* could be considered as the respective types, so that the one group would possess spirals directed with their apex towards the lateral parts of the shell, whilst the other would have obliquely ascending spirals; but as no external characters can be pointed out which would allow of the conclusion whether a certain species possesses the one or the other sort of spirals, such a distinction seems not to be practical, and the grouping of the species must be deferred until an altogether more accurate knowledge of the species of *Reticularia* will have been achieved.

Of the three species of *Reticularia* occurring in the Salt-range only one agrees specifically with a European form, *Ret. lineata*, but it must be remarked here that

the Indian shells are absolutely identical with the typical European carboniferous species. Though the species *Ret. lineata* seems to extend up into permian strata, and thus its occurrence in the Salt-range is not of very great geological importance, yet it must not be passed without mention that the Indian specimens are absolutely identical with specimens from Visé.

1. Reticularia lineata, Mart., sp.: Pl. XLII., figs. 6—8.

1809. *Conchyliolithus Anomites lineatus*, Martin: Petrif. Derbiens., pl. XXXVI., fig. 3.
1822. *Terebratula lineata* (Mart.), Sowerby: Min. Conch., Vol. IV., p. 39, pl. CCCXLIII., figs. 1, 2.
1828. *Spirifera martini*, Fleming: Brit. anim., p. 376.
1836. *Spirifera lineata* (Mart.), Phillips: Geol. of Yorksh., Vol. II., p. 219, pl. X., fig. 17.
1843. *Spirifer lineatus* (Mart.), Koninck: Descr. des anim. foss., p. 270, pl. VI., fig. 5 (pl. XVII., fig. 8 *a*, *b* ?).
1844. *Reticularia lineata ?* (Mart.), M'Coy: Synops. Carb. foss. Irel., p. 193.
1845. *Spirifer lineatus* (Mart.), Verneuil: Russia and the Ural Mountains, Vol. II., p. 147, pl. 4, fig. 6.
1855. *Spirifera* (*Martinia*) *lineata ?* (Mart.), M'Coy: Brit. Palæoz. Foss., p. 429.
1862? *Spirifer lineatus* (Mart.), Möller: Geological and pal. notes on the carb. form. of the Ural (Govnoi Zhurnal) p.? (Only a manuscript translation from the Russian is accessible to me.)
1873. *Spirifer lineatus* (Mart.), Koninck: Foss. Carb. de Bleiberg, p 55, pl. II., fig. 11.
1882. *Reticularia lineata* (Mart.), Davidson: Suppl. Brit. Sil. Brach., p. 81.

The general outline of this species is transversely oval, with rather inflated valves, the greatest thickness of which is situated not far from the apical region, The beak is not very prominent, and the area of the smaller valve is well developed. Sinus and median fold are barely indicated.

The ventral valve is slightly more strongly inflated and deeper than the dorsal one. Its curve is very regular in both directions, but has suffered a little from pressure in the large specimen figured on Pl. XLII, whereby both valves appear a little flattened in the frontal region, a character which is not observable in other specimens. The beak is not very prominent, thick, tolerably well bent over and pointed, the area small, concave, and pretty well defined. The hinge-line is considerably shorter than the greatest breadth of the shell. The triangular fissure is rather large, its width occupying not more than one-third of the entire length of the hinge-line. The front of the valve is slightly elevated and produced, but though this is the case, yet there is barely any trace of a sinus developed.

The dorsal valve is slightly less inflated and less deep than the ventral one, but otherwise its curve is very regular in both directions. The apex is very little produced, slightly bent over, pointed, and provided below with a more or less broad well-developed area, which is cut open in the middle by a very broad triangular fissure, corresponding to the same figure in the other valve. The frontal line is slightly elevated, but no distinct median fold is produced.

The surface sculpturing of the shell has been defaced in all the Indian specimens I have for description, and the hair-like hollow processes can nowhere be observed. But this sculpturing has left a very distinct impression on the deeper shell-layers, and produces there a very distinct reticulation (Pl. XLII, fig. 8*e*) which appears without a lens as a very fine radial striation. In typical specimens

of *Ret. lineata* this striation is generally not so distinct as in the Indian specimens, but this, it seems to me, is not of material importance. The character of the sculpturing is identical in both series of shells.

I have not been able to ascertain the internal characters of the Indian specimens, and therefore am not able to state whether also in this respect they agree with the European shells.

The measurements of a specimen from Amb (No. I), at the side of which I place the measurements of an equal-sized specimen from Visé (No. II.), which I owe to the kindness of Mons. de Koninck, are as follow :—

	I.	II.
Entire length of the shell	33 mm.	33 mm.
Length of the smaller valve	30 „	29 „
Entire breadth of the shell	38·5 „	38 „
Length of the hinge-line	22 „	25 „
Width of the triangular fissure	7 „	8 5 „
Thickness of both valves	23·5 „	23·5 „
Apical angle of the larger valve	93°	97°
„ „ „ smaller valve	130°	125°

Larger specimens than the one of which the measurements have been given here have not been found up to the present in the Salt-range.

Locality and geological position.—This species is extremely rare in the Salt-range, and has been detected up to the present only at two localities, where it occurs in black, coaly, calcareous sandstones in the lower division of the Productus-limestone, just at the base of the fossiliferous series above the lavender-clays. The species has been collected in these beds by myself at Amb (four specimens) and by Mr. Wynne at Vurcha (two specimens).

Remarks.—I have taken the utmost trouble to arrive at a satisfactory determination of the fossils here under consideration, and I think the course I have followed is the correct one. The Indian specimens in all respects resemble so much the specimens I have from the carboniferous limestone of Europe that I cannot but unite the Indian specimens with Martin's species. It cannot be denied that many things have been quoted by various writers under the name of *Spirif. lineatus*, Mart., the real identity of which with Martin's species remains somewhat doubtful. I have tried to bring together in the list of synonyms preceding the description of this species such quotations as appear with some certainty to relate to the typical form. Others will probably have to be added, but I am not certain on this point. From this list it appears that *Reticularia lineata* is a species of a chiefly eastern distribution, which occurs not in a single bed but extending through all the subdivisions of the carboniferous formation. It is by far most numerously represented in the mountain-limestone proper, where it is, according to the indications of Davidson as well as of Mons. de Koninck, one of the most common species. Also in the upper carboniferous limestone of the Ural the species seems to be tolerably common, but already in the uppermost carboniferous limestone of the Timan Tundra is seems to become rare, and it is very rare in the Salt-range. We shall see in the sequel that besides *Dielasma elongatum* other permian species also are there associated with it.

It remains doubtful whether the true *Reticularia lineata* has ever been found in America; it seems for the most part to be replaced there by a smaller species, which has been called *Reticularia perplexa* by M'Chesney. Other vicarious species in America are *Ret. setigera*, Hall, and *Ret. pseudolineata*, Hall.

2. RETICULARIA INDICA, Waagen: n. sp., Pl. XLIII., fig. 6, Pl. XLIV, fig 2.

1862. *Spirifera lineata* (Mart.), Davidson: Quart. Jour. Geol. Soc., Lond., Vol. XVIII, p. 29, pl. II, fig. 3.
1863. *Spirifera lineata* (Mart.., Davids.), Koninck: Fos. paléoz. de l'Inde, p. 35, pl. XI., fig 3.

Already Davidson in describing the *Spirifera lineata* from the Salt-range expressed some doubts as to the identity of this form with the typical British shells, as the Indian fossils constantly attain larger dimensions than the English ones. As, however, he could not detect other differences except the size, he did not think himself justified in distinguishing the Indian form under a different specific designation. I have now succeeded in detecting such constant differences, and therefore consider the Indian shell as representing a species different from the true *Ret. lineata*.

The general outline of the shell is nearly orbicular, but little broader than it is long, with moderately inflated valves, a prominent, not very strongly bent over beak, small not distinctly marked area, and an extremely large triangular fissure. The sinus in the ventral valve is generally rather strongly marked.

The ventral valve is slightly more strongly vaulted, and thus slightly deeper than the dorsal one. Its curve is very regular in the transverse direction, but not quite so longitudinally, this curvature being stronger in the apical than in the frontal region. The beak is very prominent, thick, pointed, and little bent over. The area is very small, concave, and not very sharply defined from the remainder of the shell by an obtusely angular edge. By far the greatest part of areal space is occupied by the extremely large triangular fissure, the width of which at the hinge-line occupies from more than one-half to two-thirds of the entire length of that line. It is never closed even partially by a pseudo-deltidium. The sinus is variously developed in this valve, but mostly it is rather distinct. The frontal part of the valve is not produced.

The dorsal valve is very slightly flatter than the ventral one and its curve is regular, but stronger in the transverse than in the longitudinal direction. The apex is well prominent, pointed and slightly bent over. The area below it is well developed and very sharply defined, cut out in the middle by an extremely large triangular fissure, so that there remains only a narrow strip of area on both sides. A median fold is not developed in this valve, but the front line is always elevated.

The surface sculpturing has been excellently described by Mr. Davidson. I regret, however, to say that among the materials accessible to my observation, no one specimen is preserved with the hair-like tubes projecting along the innumerable imbricating striæ of growth. Only the prolongations of the canals below the surface layer of the shell can be observed, they extend as fine lines between the striæ of growth and cause the fine radiately striated appearance of these shells. I cannot anywhere observe these canals piercing the deeper shell-layers.

The internal structure of this species has been tolerably completely made out by me in a silicified specimen from Musakheyl. The accompanying woodcut gives figures of both valves.



a *b*

Fig. 12. RETICULARIA INDICA, Waagen, n. sp.: internal view of both valves of a specimen from the middle Productus-limestone of Musakheyl; *a*, ventral valve; *b*, dorsal valve; both natural size.

In the ventral valve not a trace of dental plates or a median septum is observable. The hinge-teeth are small and situated on both sides of the extremely large deltidial fissure. This latter is limited laterally by sharp shelly margins, which are followed more interiorly by a prominent bent-down shelly lamella. The apex of the valve is limited off from the deltidial fissure by a vaulted shelly lamella, which is, however, quite inside the fissure, and can be observed from outside only with difficulty. It does not seem to me that this lamella can be taken as replacing the pseudodeltidium. The muscular impressions can be well observed in this valve in a general way. They occupy a very elongately oval excavated space about in the middle of the valve, but how this space is subdivided cannot be seen distinctly.

In the dorsal valve the area is reduced to mere narrow strips on both sides of the extremely large triangular fissure, at the end of which strips the small dental grooves are situated. Immediately below the little incurved apex a kind of incomplete visceral foramen is situated, on both sides of which the internal margins of the crura take their origin. The crura begin as broad, flat, shelly lamellæ, which are fixed with their broad oblique base to the inner wall of the dental sockets from near the apex of the valve down to the end of the socket walls. From their base the crura are quickly tapering, and approach each other more and more towards the frontal region. On this portion of their extent they form tolerably straight, flat, shelly bands, any kind of spur or loop being completely absent. Not far from the frontal margin they suddenly bend upwards and outwards and then again a little inwards, still presenting the broad face of the band. Then suddenly the band turns its edge to the observer, becomes narrower and forms the first volution of the spiral. The apex of the spirals is directed towards the hinge-line. The number of volutions in each spiral cannot exactly be counted, and the number indicated in the drawing must not be taken as absolutely correct, though it is approximately so.

The muscular impressions in this valve cannot be distinguished.

The measurement of two specimens, No. I from Chidru and No. II from Musakheyl are as follow:—

	I.	II.
Entire length of the shell	61 mm.	48 mm.
Length of the smaller valve	54 „	43 „
Entire breadth of the shell	65 „	47 „
Length of the hinge-line	26 „	21 „
Width of the triangular fissure	17 „	18 „
Thickness of both valves	36 „	25 „
Apical angle of the larger valve	105°	102°
„ „ „ smaller valve	125°	130°

The specimen No. I represents the average size of the specimens occurring in the Salt-range. Mr Davidson has figured a much larger shell, measuring not less than 81^{mm} in length and 87^{mm} in breadth. Such gigantic specimens are rare in the Salt-range. But also smaller specimens are not common. The specimen No. II is among the smallest that have been observed by me.

Malformations of this species are not very rare, as in the one figured in Pl. XLIV, fig. 2.

Locality and geological position.—This species is nowhere common, but it occurs in many localities. It is almost entirely restricted to the middle division of the Productus-limestone; only a single doubtful fragment has been detected by Mr. Wynne in the upper division. In the middle division it has been found by Dr. Oldham at Chidru in light-coloured marly limestones (three specimens). Mr. Theobald collected it at a locality that is not exactly known (one specimen); Mr. Wynne brought two specimens from Khund, preserved in a white saccharoid limestone. I myself collected the species at Virgal in the coral- as well as in the crinoid-beds (three specimens), in the mountains east of Katwáhi in hard limestones (two specimens), and in the Chittawán (one specimen). By Dr. Warth three specimens of it were found at Musakheyl.

As has been already mentioned, Mr. Wynne collected a fragment of a ventral valve doubtfully belonging to this species at Khund Ghát in the upper division of the Productus-limestone.

Remarks.—This species has been identified by Mr. Davidson with *Ret. lineata*, Mart., and it cannot be denied that the form is extremely nearly related to Martin's species; nevertheless differences can be pointed out which are constant and easily detected.

There is firstly the great size of the Indian specimens; however remarkable, this could not indeed constitute a specific difference, but occurring with other peculiarities it is of great importance. Another peculiarity consists in the extremely large triangular fissure, which is of such an extent that it mostly occupies more than half of the areal space. This deltidial fissure is so very large that the specimens of this species almost resemble young specimens of *Stringocephalus burtini*, in which also so enormous a deltidial fissure is present. If this fissure, no pseudo-deltidium having ever existed, was entirely filled by the peduncle, then this organ had in the species here under consideration a development not less strong than in the living

Lingula. The size and the enormous triangular fissure below the beak are then the chief differences that I can point out in the present species in comparison with the true *Ret. lineata*. Yet another difference might perhaps exist in the internal structure, as the present species combines the internal characters of *Reticularia imbricata*, Sow., with the external shell sculpturing of *Ret. lineata*. It remains, however, doubtful whether great stress can be laid on this peculiarity.

From all that has been said it appears more than probable, that we have to deal here with a species entirely different from *Ret. lineata*. The differences are not great, it is true, but it must be taken into consideration that in the genus *Reticularia* in general the differences between the several species are very small, and that most of the species which now are considered to constitute the genus *Reticularia* were a short time ago taken as belonging to only one species.

3. Reticularia elegantula: Waagen: n. sp., Pl. XLIV, fig. 1.

This is a species of moderate size, with flat valves and a very delicate little beak. The general outline of the shell is nearly orbicular, the sculpturing of the valves very neat and regular.

The ventral valve is rather flat, but very regularly curved in both directions. It is not deeper than the dorsal one. The beak is very thin, but not long, and little prominent. It is pointed, and its apex is well bent over. The area is tolerably large and strongly reclining, at the same time nearly flat, but very little concave. It is distinctly defined from the remainder of the shell by sharp edges, which extend from the apex of the beak to the end of the hinge-line. The latter is not very much shorter than the greatest breadth of the shell. In the middle it bears a large triangular fissure, which is, however, not so large as in the preceding species. A pseudo-deltidium has not been observed by me. A median sinus is present in this valve, but it is very shallow, producing only a very slight upward curve of the front-line; nevertheless it extends for quite two-thirds of the length of the valve.

The dorsal valve is also very little vaulted, but is not flatter than the ventral one. It is very regularly curved in both directions. The apex is promiment, pointed, and strongly bent over, bearing on its inner side a narrow but very sharply defined area. This is cut out in the middle by a very large triangular figure, so that on both sides of it only narrow strips of the area remain. Not a trace of a median fold is ever developed in this valve, though the front-line is slightly bent up in the middle.

The sculpturing exhibited by both valves of this species is very characteristic. It consists of very regular concentric folds, which are not very close together, and are roof-shaped, with two sloping faces, one towards the frontal line and one towards the apical part of the shell. In this way a sharp crest is formed, which is occupied by a closely arranged row of erect hair-like spines. These spines are, however, everywhere broken off in the specimen I have for description, and only their bases can be observed. These are placed like a string of closely set very fine beads on the crests of

the concentric folds. Each of these beads bears a little pore in the middle, which can however only be observed with a very powerful lens. I have never seen in this species a double-barrelled spine. The fine radial striation which is brought about by the mode of sculpturing in *Reticularia lineata* is almost quite absent in this species, and only with difficulty a kind of radial striation can be seen in certain places.

The internal characters of this species could not be observed by me.

The measurements of a specimen from Morah are as follow:—

Entire length of the shell	35	mm.
Length of the smaller valve	33	„
Entire breadth of the shell	39	„
Length of the hinge-line	22	„
Width of the triangular fissure	9·5	„
Thickness of both valves	19	„
Apical angle of the lower valve	85°	
„ „ „ smaller valve	118°	

Locality and geological position.—The only specimen of this species that has been found up to the present was collected by Mr. Wynne in reddish marble-like limestones at Morah, and comes beyond doubt from the middle division of the Productus-limestone.

Remarks.—The species here under consideration is chiefly characterised by its thin little-prominent beak and its peculiar sculpturing. By these two characters it can easily be distinguished from *Ret. lineata* as well as from *Ret. imbricata*. These latter two species have their sculpturing arranged as fringes which project from imbricating striæ of growth, but the fringes are not erect and placed on the top of roof-shaped concentric folds, as it is the case in *Ret. elegantula*.

The type of sculpturing observable on *Ret. lineata* and *Ret. imbricata* is, however, not the only one which occurs in Europe within the genus. Another type is exhibited by a species which occurs at Visé together with *Mart. glabra*, &c., in black hard limestones, and which has been figured by Mons. de Koninck (Descr. des Anim. foss.) on Pl. XVII, figs. 8 *d*, *e*. This form is beyond any doubt specifically different from *Ret. lineata*, with which it has been generally united, and I shall quote it in the future under the name of *Reticularia koninckı*, Waagen. Its sculpturing consists of more or less distinct, interrupted, radial undulations, each of which bears only one hair-like spine, apparently erect. The spines themselves are nearly always lost, but there remain distinct round scars, where they have been situated, which are comparatively large and far separated from each other. On the whole they very much resemble on a small scale the round stigmata exhibited by the genus *Stigmaria*. This kind of sculpturing seems to be more widely separated from the mode of sculpturing occurring in the typical species, than that which I have described above as being observable in *Ret. elegantula*. From these observations it appears that the singular sculpturing which has already led to the distinction of the genus, is subject to a number of more detailed variations, which can be made useful for the distinction of species.

III. Sub-Order: APHANEROPEGMATA, sive PRODUCTACEA.

Family: *PORAMBONITIDÆ.*

Up to very recent times the shells belonging to this family were but rather incompletely known, and the relations of the family to other groups of Brachiopods could only be more or less guessed at. A short time ago, however, a paper by Noetling appeared in the "Zeitschrift d. Deutsch. Geolog. Gesellschaft," which gives very explicit details as to the internal structure of these shells, so that the systematic placement of them does not any longer encounter unsurmountable difficulties. By Noetling himself the systematic position of the genus *Porambonites* has been assigned in the following manner: he demonstrates that rather close affinities exist on the one hand between this genus and *Orthisina*, and on the other hand between it and *Pentamerus*. According to Dr. Noetling's description, these affinities seem in fact well founded, and *Porambonites* appears as a strange intermediate link between the *Pentamerinæ* and the *Aphaneropegmata* as a body. Nevertheless I should not like to affiliate the genus *Porambonites* so closely with the genus *Pentamerus* as to unite the two genera into one family, *Porambonitidæ*, and to separate the latter genus altogether from the *Rhynchonellidæ*, as has been done by Noetling. The chief objection to be made against such a proceeding lies in the structure of the shell of *Porambonites*, in which both valves bear a small but distinct area, and both possess a triangular open deltidial fissure. These characters approach *Porambonites* more to the *Orthis*-like shells than to the *Rhynchonellidæ*, from which latter family the genus also deviates by the constant absence of any kind of crura. On the whole, even after the very able exposition of the interior of these shells by Noetling, the genus still appears to be so peculiar that it may well be considered as forming a family by itself—a view that has been long since held by Davidson and others.

Yet another genus has been brought by Zittel into close connection with *Porambonites;* it is *Syntrielasma*, Meek, a genus which is for us of special interest as being rather largely represented in the Salt-range. It cannot be denied that the genus exhibits a certain affinity to *Porambonites*, but this affinity seems not to be closer than that existing between the latter genus and *Orthis*. But since at the same time certain peculiarities in the internal characters of *Syntrielasma* occur, by which the genus deviates widely from *Porambonites*, whilst just by these peculiarities it appears more nearly related to *Orthis*, I have preferred to place the genus in the family *Orthidæ* instead of in *Porambonitidæ*.

We thus see that by the genus *Porambonites* the *Aphaneropegmata* are linked to the *Rhynchonellidæ*, and especially to the *Pentamerinæ*, rather than to any of the

Helicopegmata, whilst the latter on the contrary are linked on their part again to the *Rhynchonellidæ* by the family *Atrypidæ*.

If we exclude the genus *Syntrielasma* from the family *Porambonitidæ*, then the family is not represented in the Salt-range.

Family: *ORTHIDÆ*.

In contravention of the general rule, I must, though reluctantly, separate a family *Orthidæ* from the remainder of the *Strophomenidæ*. If we attentively examine the features by which the genus *Orthis* is characterised, there is chiefly one point deserving special attention; this is the existence of rudimentary crura in the dorsal valve on both sides of the cardinal process—a feature which is absolutely absent in all the other genera of *Strophomenidæ*. By this feature the *Orthidæ* more nearly approach the *Rhynchonellidæ* than might appear on a first glance, and by the existence of these crura the *Orthidæ* are characterised as a truly transitional group, which link once more the *Aphaneropegmata* to the *Rhynchonellidæ* proper.

The crura are but very little developed in *Orthis* itself. More strongly, and even stronger than in most of the *Rhynchonellidæ*, are they developed in *Syntrielasma* or *Enteletes*, as the genus must more properly be called. The presence of such large crura has even induced Mr. Dall to place the genus *Syntrielasma* altogether in the family *Rhynchonellidæ*.

The existence of these crura, the smallness of the cardinal process in the dorsal valve, the occurrence of a more or less large area in both valves, with a large and always open deltidial fissure, all these characters serve to distinguish the family *Orthidæ* from the *Strophomenidæ* proper, and I think the distinction can very well be sustained also on geological grounds.

The family is a very small one, and there are only a few genera that can be placed in it. Nevertheless I am able to distinguish easily two sub-families. The first of these contains only one genus. I shall call it

Sub-family: *ENTELETINÆ*.

The genus of which this sub-family is composed is Enteletes, Fisch. v. Waldh., a name which must replace the name *Syntrielasma*, Meek, now generally used for these forms. The accurate description of this genus will follow further on.

The second sub-family will bear the name

Sub-family: *ORTHINÆ*.

This sub-family is composed of the following genera:—

1. Orthis, Dalman, 1828 (Kongl. Vetensk. Acad. Handl., 1827, pp. 93, 96).

Crura very small, hingeline shorter than the greatest breadth of the shell; shell radially striated externally: cambrian to permian.

2. Bilobites, Linné, 1775 (Syst. Nat., ed. Müller, VI., p. 325). Shell small, bilobed, with large, thin, wing-shaped crura in the dorsal valve: silurian and devonian.

3. Platystrophia, King, 1850 (Monogr. Brit. Perm. Foss., p. 106). Crura as small as in *Orthis*, hingeline as long as or longer than the greatest breadth of the shell; shell externally strongly plicated radially: silurian.

4. Skenidium, Hall, 1860 (13th Regents Rep. New York State Cab., p. 70, Dec. f. 2. 4. 5).=*Mystrophora*, Kays. *Orthis*-like, small, with a very large median septum in the dorsal valve: silurian and devonian.

5. Orthoidea, Friren, 1875 (Bull. Soc. Hist. Nat. de Metz, 2de sér., cahier 14, p. 1, Pl. I, f. 1—6). Internal structure known only from internal pyritic casts, but seems not to differ much from that of *Orthis*. Externally the shell without radial striation; smaller valve without an area: middle-lias.

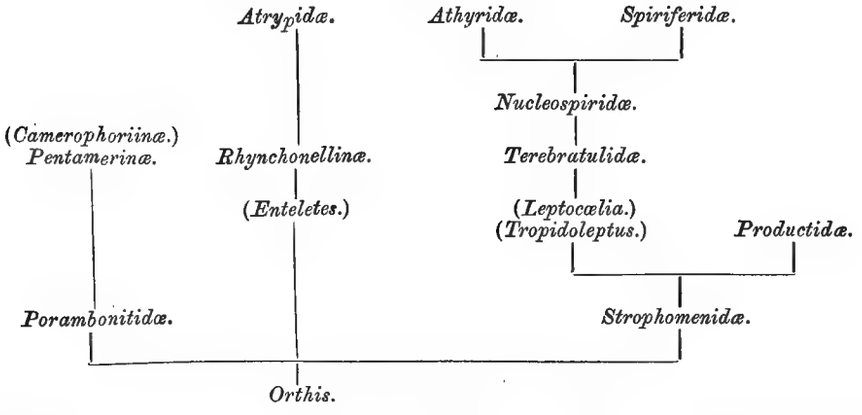
From this review of the genera it appears that the *Orthinæ* range from the cambrian to the middle-lias, but that though the geological range is very extensive, yet the variety of forms is very limited. It cannot, however, be passed in silence that the geologically oldest known species of the *Arthropomata* belong to this sub-family, as the oldest known *Arthropomata* occurring in the cambrian period belong to the genus *Orthis*. This is the reason why it is of so much interest to point out the affinities between the *Orthidæ* and other groups of *Brachiopoda*. I have already indicated above, in treating of the family *Porambonitidæ*, that the affinity between this family and *Orthis* was very great; this is even the case to such an extent that I was for a long time in doubt whether I should not consider the *Porambonitidæ* as a sub-family only of the *Orthidæ*.

On the other hand, again, it has been pointed out that between *Orthis* proper and *Rhynchonella* there exists a certain affinity, which is chiefly marked in the genus *Enteletes*—a genus which has been united by Dall directly with the *Rhynchonellidæ*. From these latter we come to the *Atrypidæ*, which are considered by most authors as very nearly related to the *Rhynchonellidæ*.

A third series of affinities exists between *Orthis* and the remainder of the *Aphaneropegmata*. There come first *Orthothetes*, *Streptorhynchus*, &c., which link the genus *Orthis* to *Strophomena*, and the near affinity of the latter genus to the *Productidæ* has been demonstrated most recently by Neumayr, who detected the occasional occurrence of reniform impressions in *Strophomena*. From *Strophomena*, again, we pass through Hall's genera *Tropidoleptus* and *Leptocœlia* (which show in general a certain affinity with *Strophomena*) to the *Terebratulidæ* with an entire and complicated loop, and from these to the *Nucleospiridæ*, *Athyridæ*, and *Spiriferidæ*.

It is, then, of great interest that the geologically oldest genus, *Orthis*, should be

the one from which all these affinities take their origin. If we bring these affinities into a tabular view we get the following scheme :—



This scheme is the key to the affinities of all the *Arthropomata*, with the exception of the *Thecideidæ* and the *Stringocephalidæ*. These two groups stand apart from the rest.

It is now very seducing to take this scheme as also representing the appearance in time of the different groups, and as showing their developmental connection. To a certain extent this may be in fact the case, but at all events the scheme shows what way the development of the *Arthropomata* may have taken to arrive at the more complicated forms of the *Rhynchonellidæ*, *Atrypidæ*, *Productidæ*, and *Terebratulidæ*, starting from the geologically oldest genus *Orthis*. The succession in time of the different groups does not oppose the idea of their being in a developmental connection; and as far as regards the *Porambonitidæ* and *Petamerinæ*, such a connection has been advocated already by Noetling, but the direct proofs, the connecting species between the different groups, have in most cases not yet been detected, and we must look forward for them in the future.

In the Salt-range the family *Orthidæ* is represented by two genera—the sub-family *Enteletinæ* by the genus *Enteletes* and the sub-family *Orthinæ* by the genus *Orthis*.

Sub-family : *ENTELETINÆ*.

Genus : ENTELETES, Fisch. v. Waldh.

1830. *Enteletes*, Fischer von Waldheim : Oryctogr. du Gouv. de Moscou, p. 144., Pl. XXVI, figs. 6, 7.
1845. *Spirifer* (*lamarcki*), Verneuil : Murch. Vern. Kays. Geol. of Russia, Vol. II., p. 152, Pl. 6, fig. 8.
1865. *Syntrielasma*, Meek : Proc. Acad. Nat. Sci., Philad., Dec., 1865, p. 277.; Geol. Rep., Illinois, Vol. II, p. 321, figs. 36, 37.
1876. *Orthis* (*lamarcki*), Trautschold : Mjatschkowa, II, p. 70, Pl. VII, fig. 3.
1883. *Syntrielasma* (Meek), Kayser : Richthofen's China, Vol. IV, p. 179, Pl. XXIV, figs. 2, 3.

Though the characteristic of the genus, as given by Fischer von Waldheim, is very insufficient, yet the species, which is represented on Pl. XXVI, figs. 6 & 7 of his work, can very easily be recognised and identified with *Choristites* or *Spirifer*

or *Orthis lamarcki*—a species which is very characteristic for the upper carboniferous-limestone of Mjatschkowa, from which locality also the original specimen of *Enteletes* came.

Fischer von Waldheim characterises his genus in the following manner: "Coquille sub-arrondie ressemblant pour la forme à une Térébratule, présentant de petits becs sur les deux valves, mais la charnière est tellement unie et close, que les deux bords avancent un pen au dessus de la coquille.

"La charnière est très courte."

It is evident that this description was drawn up from a somewhat compressed specimen, in which the hinge-margin of one valve was shifted above that of the other—a mode of preservation which is not at all rare in the genus. But though we may make allowance for such a mode of preservation, yet it cannot be denied that the characteristic of the genus as given by Fischer von Waldheim is quite useless, and cannot in any way serve for the right understanding of what is to be taken as forming part of the genus.

Nevertheless the name *Enteletes* cannot be erased from the pages of scientific literature; and as it can be easily made out from the figure as well as from the locality whence came the original specimen of *Enteletes*, what was originally understood by the name, there is, I think, no escape from making use of it. It is, however, to be regretted that the shells which must bear the name of *Enteletes* are generically identical with what has been described by Meek under the name *Syntrielasma*. The genus has been very well characterised by Meek, and I should have gladly retained his designation, if it had been already in general use, and sanctioned by a long-continued practical application. This is, however, not the case, and the name has up to the present only been rightly applied by few people. Zittel, for instance, in his hand-book has entirely misunderstood Meek's genus: he quotes *Enteletes* as a sub-genus of *Orthis*, and refers *Syntrielasma* to the family *Porambonitidæ*, though the two are identical. Under such circumstances, I think it best to go back to the old name *Enteletes*.

The genus *Enteletes* may be characterised as follows:—

The general outline of the shell is more or less globular, with mostly very strongly inflated valves. The hingeline is short, never projecting, both valves are more or less strongly plicated radially.

The ventral valve is always smaller than the dorsal one. The area of the ventral valve is sometimes high and strongly reclining, sometimes not; but laterally little extended, according to the short hingeline. It is cut open in the middle by a tolerably large triangular fissure, which is never covered up by a pseudodeltidium.

The dorsal valve is always larger than the ventral one, with a strongly bent over and sometimes even rolled-in beak. The area is mostly small in this valve, and even sometimes linear. The deltidial fissure is smaller than in the other valve.

Both valves are covered all over with a very fine radial striation, similar to that occurring in many species of *Orthis*, and it appears not improbable that also in

Enteletes fine hair-like spines were disseminated irregularly over this striation. The minute structure of the shell is punctate.

These are the external characters. Internally the ventral valve bears two strong elongated teeth on both sides of the triangular fissure, supported by very strong dental plates, which extend from the apex towards the front of the valve; but instead of diverging they approach each other towards the middle of the valve, bending round either with a gentle curve or with a sudden bend. Between these dental plates, beginning as a low ridge at the apex, a thin blade-like median septum extends; it is highest towards the middle of the valve, and then suddenly terminates (Pl. LVII, fig. 5*b*).

The dorsal valve has interiorly two very strong septa, which extend on both sides of the deltidial fissure and project for a certain distance, strongly diverging into the interior of the valve. They support strong and long curved crura, which have exactly the shape of a boar's tusks. They are laterally compressed, and bear on their lower and inner side a sharp prominent ridge. The dental sockets are placed exteriorly to the origin of the crura. In the middle, at the apex of the valve, a small cardinal process is observable, having the form of a short narrow ridge.

These characters will suffice to recognise the genus and to distinguish it readily from other allied forms.

The exterior shapes of the shells belonging to the genus are more or less variable, and chiefly remarkable in this respect is the shifting of the median sinus from one valve to the other, which to such an extent has only been observed besides in the genus *Pentamerus*.

There is one series of forms, the typical one, in which the sinus is on the ventral valve, and the dorsal valve bears a corresponding median fold. To this series belongs the *Enteletes glaber*, Fisch., and *Enteletes lamarcki*, Fisch., of Russia; and the *Enteletes hemiplicatus*, Hall, sp., from the upper coal-measures of America. This series is represented in India by two species—*Ent. kayseri*, W., and *Ent. lævissimus*, W.

The other series, in which the median sinus is on the dorsal valve and the ventral valve bears the corresponding median fold, is composed of five Indian species, which all occur in the Salt-range. The South American species, *Ent. andii*, Orb., and *Ent. gaudryi*, Orb., cannot well be classed, as the septa characteristic of the ventral valve have not been observed, and thus it is not known for certain which valve is the ventral one. But that the series with a sinus in the dorsal valve is not entirely absent in America, appears highly probable from Geinitz's figure and description of his *Rhynch. angulata*, L., from Nebrasca. The interior of the larger valve, which he figures Pl. III, fig. 2, beautifully represents the internal structure of the dorsal valve of *Enteletes*, and the fig. 1*b*, in which, as is distinctly stated by Geinitz, the smaller valve is above and the larger one below, shows beyond any doubt a median sinus in the larger, that is to say, in the dorsal valve. The peculiarities of these two groups can well be used for the distinction of two different

sections within the genus, the first of which I shall call the "*Ventrisinuati*," the second the "*Dorsosinuati*."

The Salt-range species are distributed through the middle and upper divisions of the Productus-limestone. The geologically oldest species is *Enteletes ferrugineus*, W., which occurs in the lower region of the middle Productus-limestone, and which is most nearly related to *E. andii*, Orb., and the species figured by Geinitz from Nebrasca. Next come *Enteletes pentameroides*, W., and *Ent. sublævis*, W., from the middle region of the middle Productus-limestone, and then *Enteletes latesinuatus*, W., from the upper region of the middle Productus-limestone of Musakheyl. The geologically youngest species is *Ent. acuteplicatus* from the upper Productus-limestone.

All these species are very nearly related to each other, and in part most likely in developmental connection; I can distinguish two groups: the one starts from *Ent. ferrugineus*, W., and proceeds through *Ent. sublævis*, W., to *Ent. latesinuatus*, W.; the other takes its origin from *Ent. pentameroides*, W., and terminates in *Ent. acuteplicatus*, W.

The section of the *Ventrisinuati* commences with *Ent. kayseri*, W., in the middle region of the middle Productus-limestone, and terminates with *Ent. lævissimus*, W., in the upper region of the same formation. It is probable that both species belong to a group of forms of which *Ent. hemiplicatus*, Hall., is the type.

I. Section: VENTRISINUATI.

A.—Group of *ENTELETES HEMIPLICATUS*, Hall, sp.

1. Enteletes kayseri, Waagen: n. sp.

1882. *Syntrielasma hemiplicata* (Hall), Kayser, in Richthofen's China, Vol. IV, p. 179, Pl. XXIV, figs. 2, 3 (*non* Hall).

This species is very badly represented in the Salt-range collection, and it is only from a single ventral valve that I can state its occurrence there.

The truly beautiful figures of this species published by Professor Kayser, as well as his excellent description, make it easy to recognise the species even in a fragmentary condition, and I think the determination of the Indian specimen cannot be subject to any doubt. All the features indicated as characteristic of the Chinese shell are found again on the Indian specimen.

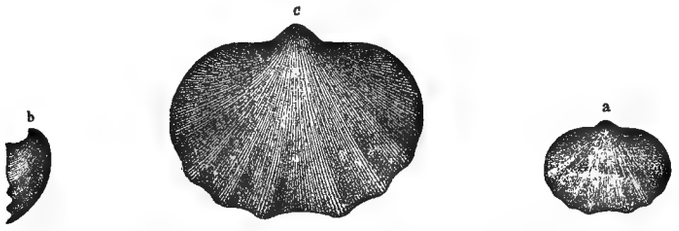


Fig. 13. Enteletes kayseri, Waagen, n. sp. Ventral valve from the middle Productus-limestone of Swás
a, ventral view; *b*, lateral view, both natural size; *c*, ventral view, enlarged.

The ventral valve is comparatively flat, with a slightly bent-over apex, and a comparatively large triangular area, which is cut open in the middle by a deltidial fissure. The area is reclining and but very little concave. The valve is smooth for fully one-third of its extent, then a broad median sinus begins to appear, which is followed on each side by three short narrow folds. Of the three septa only traces can be discerned on the specimen at hand.

The radial striation of the shell is fine and distinct.

The measurements of the specimen are as follow:—

Entire length of the valve	13 mm.
„ breadth „ „	17 „
Height of the area	2·5 „
Apical angle	121°

Locality and geological position.—The only ventral valve of this species that is known to me was collected by Dr. Oldham at Swás in the middle region of the middle Productus-limestone.

Remarks.—This species was described originally by Professor Kayser from Lo-Ping in China from upper-carboniferous beds under the name of *Syntrielasma hemiplicata*, Hall. At the time of publication of Kayser's work no other species of *Syntrielasma* or *Enteletes* were known, except the above species of Hall, and *Syntrielasma lamarcki*, Fisch. Of these two species the first one is beyond doubt by far more nearly related to the Chinese shells than the other, and thus it is very well explainable how Mr. Kayser came to identify his specimens with Hall's species. Now, however, after so many species from the Salt-range are known to me, the range of variation of the single species can more easily be judged, and accordingly it seems highly probable that the Chinese shells represent a species different from *Ent. hemiplicatus*.

One of the differences has been indicated already by Mr. Kayser; this is the hingeline, which is considerably longer in the Chinese than in the American shell. Other differences consist in the much broader and less deeply sunk-in sinus of the ventral valve and in the sharper and narrower lateral folds. It needs only a comparison of the frontal view of both species to remark immediately the great differences that exist.

I therefore consider the Chinese and the Indian specimens as forming a species different from *Enteletes hemiplicatus*, and introduce for it the name of *Enteletes kayseri* in honour of its first describer.

2. Enteletes lævissimus, Waagen, n. sp.

This species is of rather small size, with nearly quite smooth valves, which are very little different in size, the dorsal valve being but little larger than the

ventral one. In its whole outward appearance this species approaches very near to *Orthis*.

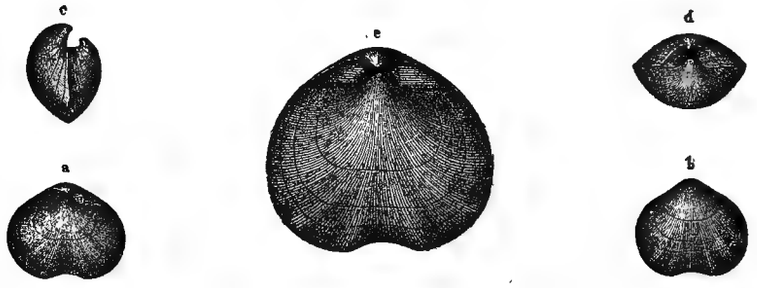


Fig. 14. ENTELETES LÆVISSIMUS, Waagen, n. sp. Specimen from the middle Productus-limestone of Bilot: *a*, ventral view; *b*, dorsal view; *c*, lateral view (the ventral valve to the right is much too small—see measurements); *d*, cardinal view, the ventral valve above,—the four figures natural size; *e*, ventral view enlarged.

The ventral valve is rather flat. Longitudinally its curve is considerably stronger in the apical than in the frontal region; the transverse curve, however, is very regular. The apex is strongly pointed and little bent over. The area is sharply defined and comparatively large, cut open in the middle by a large deltidial fissure. It is very strongly reclining and but little concave. The valve is entirely smooth for a little less than half its extent from the apex, then a shallow median sinus begins to appear and extends down to the front, but is not limited on both sides by elevated ridges. On each side of the sinus, a little distant from it, a very slight trace of a lateral rib is indicated. Otherwise the valve is entirely smooth.

The dorsal valve is but little larger than the ventral one, and considerably more vaulted, the curve being very regular in both directions. The apex is strongly bent over and pointed. It overhangs a small but very sharply defined area, which is nearly vertical, and cut open in the middle by a large deltidial fissure. The area is but little concave. This valve is entirely smooth for fully two-thirds of its extent from the apex. Then only a very low and rounded, rather broad median fold appears, and extends down to the front. It is followed on each side by a faint indication of a short, narrow, lateral fold. Otherwise the valve is entirely smooth with the exception of some more strongly marked striæ of growth which appear from distance to distance on both valves.

Of the interior characters of this species nothing is known to me.

The radial striation of the shell, which is characteristic of the genus, is very fine in this species.

The measurements of the only existing specimen are as follow:—

Entire length of the shell	14 mm.
Length of the ventral valve	13 „
Entire breadth of the shell	16·5 „
Length of the hingeline	8·5 „
Entire thickness of the shell	10 „
Height of the area in the ventral valve	3 „
„ „ „ dorsal „	2 „
Apical angle of the ventral valve	115°
„ „ „ dorsal „	107°

Locality and geological position.—The only specimen of this species that is known to me was collected by Mr. A. B. Wynne, at Bilot, trans-Indus, in the topmost beds of the middle division of the Productus-limestone.

Remarks.—This species appears to be rather nearly related to the one described before; there are nevertheless differences which led me to distinguish the present form specifically. These differences consist chiefly in the large area of the ventral valve, and in the presence of only one lateral fold on each valve, instead of three as in the preceding species. This cannot be a difference caused by difference of age, as in the specimen of *Ent. kayseri* from Swás, which is of equal size, all the folds are already developed, and as also according to Kayser's figures all the folds of *Ent. kayseri* were developed at the same time.

II. Section: DORSOSINUATI.

A.—Group of *ENTELETES FERRUGINEUS*, Waagen.

3. Enteletes ferrugineus, Waagen, n. sp.; Pl. LVII, figs. 7, 8.

There is no complete specimen of this species in the Salt-range collection; but the strong and comparatively sharp radial folds which, chiefly in the ventral valve, reach up to the apex, and by which the species can easily be recognised, make a distinction of it desirable.

The species is not large, not even quite of a medium size. It is transversely oval in outline, with the valves moderately inflated. The difference in size of the two valves is very small, and it appears from some fragments as if in this species the ventral valve sometimes exceeded slightly in size the dorsal one. The front margin of both valves forms a very strongly and sharply zig-zag line.

The ventral valve is moderately arched, somewhat flatter than the dorsal one. It bears in the middle a highly elevated median fold, which is followed on each side by three lateral folds. The median fold is the broadest and at the same time the highest of all; the lateral folds gradually diminish in height and breadth. The apex and area of the ventral valve are concealed by rocky matter. The valve is covered with sharp striæ of growth which bend up and down in zig-zag lines, as at the margin of the valve. They are chiefly heaped together near the margin, where they cause a kind of truncation to be formed. The fine radial striation characteristic of the genus is well and sharply developed in this valve.

Of the interior characters of the valve, the existence of the three septa can well be observed.

The dorsal valve is slightly more strongly vaulted than the ventral one, and seems also to be mostly larger than the other, but the difference in size is not considerable. It bears in the middle a tolerably broad and deep median sinus, which commences already at the apex of the valve. It is limited on both sides by high

and tolerably sharp folds, which are followed on each side by two other folds, and a very slight indication of a third. The lateral folds do not reach the apex of the valve. Also in this valve many zig-zag striæ of growth can be observed; they are, however, not so sharp as those of the other valve. The fine radial striation is identical on both valves. The area of this valve is narrow but very sharply defined and strongly concave. The deltidial fissure is wide, the apex of the valve apparently slightly truncated. Of the internal characters of this valve the extremely strong and massive crura are well observable. They are comparatively short and composed of two blades, one vertical, which limits the dental socket on the inner side, and one horizontal, which is fastened below to the vertical one, and projects laterally towards the deltidial fissure. These crura are fixed on their outer side to two strong diverging septa which support the dental sockets. The cardinal process in the middle of the apex is not well preserved.

I cannot give exact measurements of this species, as the materials at hand are too fragmentary to do so.

Locality and geological position.—There are altogether only two valves of this species known to me; both were collected by Mr. A. B. Wynne at Omarkheyl in the trans-Indus continuation of the Salt-range. The specimens are contained in a hard yellowish marble, which bears many silicious particles. These latter, if the rock is disintegrated by weathering, take a blackish-brown colour, and remain standing out on the surface, and this is the state in which the two valves are preserved. In the Salt-range proper this mode of preservation is characteristic of the lower division of the middle Productus-limestone, and therefore I think I shall not be very wrong in assigning a similar position to the specimens from Omarkheyl.

Remarks.—The species here under consideration is of special interest on account of its general resemblance to *Ent. andii*, Orb., from the upper carboniferous-limestone of Bolivia. The similarity between the two shells is in fact so great that I should have unhesitatingly united the two, if I could have found out whether the specimen figured by d'Orbigny was a dorsal or a ventral valve. If the latter were the case the identity would be highly probable, but otherwise the shell would belong to an entirely different section of the genus.

Also the shell figured by Geinitz from Nebrasca under the name of *Rhynchonella angulata*, L., is rather similar to the species here under description. I have already stated above that this shell probably belongs to the section "*Dorsosinuati*," and so far it can be well compared to the Indian species. Nevertheless the two forms cannot be identified. The American shell is about as long as it is broad, and in both valves the folds begin only at a certain distance from the apex, both being characters which do not agree with those of the Indian species.

It is, however, of special interest to observe that the geologically oldest species of the Salt-range is the one which is most nearly related to the American coal-measure forms.

4. Enteletes sublævis, Waagen, n. sp.; Pl. LVII, figs. 1 & 3.

The general outline of the species is slightly broader than it is long; the dorsal valve is considerably larger than the ventral one, and both valves are rather strongly inflated; the smaller valve is nearly smooth, the larger rather strongly plicated.

The ventral valve is moderately inflated, much less so than the dorsal one, and its curve is tolerably equal in both directions. The apex is pointed and well bent over, with a small and not very distinctly defined area below, which is considerably concave. The deltidial fissure in the only specimens is covered by rock matter which could not be removed. The hingeline is very short, measuring barely more than half the transverse diameter of the shell. At the apex of the valve a low median fold, which is at first barely visible, begins to be formed, and extends down to the front line, but even in this vicinity it does not attain much size. Its breadth is also moderate. Lateral folds are almost quite absent, and only in the vicinity of the margin of the shell slight traces of two lateral folds appear. Otherwise the lateral parts of the valve are smooth. There are some more or less distinctly marked striæ of growth disseminated over the valve. The radial striation is distinct when the shell is well preserved.

The dorsal valve is much more strongly inflated than the ventral one, but its curve is also tolerably equal in both directions. The apex is prominent and inflated, and very strongly bent over. It is a little truncated, forming a kind of small semicircular foramen. The area is sharply defined but extremely narrow, nearly linear, and very strongly concave. At the very apex of the valve there commences already a distinct, tolerably broad and deep median sinus, which gets more and more strongly marked as it approaches the frontal margin. It is limited on both sides by prominent and strongly marked rounded folds. These are followed again by two well marked, rounded lateral folds on each side. These latter do not however commence immediately at the apex, but at a more or less considerable distance from it. Young specimens in consequence appear nearly quite smooth, with the exception of the median sinus in the dorsal valve.

Of the internal characters the three ventral and the two diverging dorsal septa can be very well seen in a young specimen.

The dimensions of two specimens are as follow:—

	I.	II.
Entire length of the shell	28 mm.	15·5 mm.
Length of the ventral valve	20·5 „	14 „
Entire breadth of the shell	24 „	17·5 „
Length of the hingeline	13 „	9 „
Entire thickness of the shell	21 „	12 „
Apical angle of the ventral valve	105°	107°
„ „ „ dorsal valve	88°	90°

Locality and geological position.—There have altogether two specimens of this species been found up to the present, which were collected by Mr. Wynne. The

largest of them comes from hard limestones of the Chittawán, forming there the middle region of the middle Productus-limestone. The second specimen was collected at Shekh Budín (trans-Indus). It is contained in a hard grey limestone, forming probably also part of the middle division of the Productus-limestone.

Remarks.—This species on a first glance seems to be rather similar to *Enteletes hemiplicatus*, Hall, sp., but on closer examination one soon finds that the American species has its sinus in the ventral valve, whilst the Indian shell has it in the dorsal one, and thus a comparison between the two shells can in reality not be undertaken.

From *Enteletes ferrugineus*, W., the present species can be distinguished easily by its nearly quite smooth ventral valve, whilst in the former one the same valve is strongly plicated.

3. Enteletes latesinuatus, Waagen, n. sp.; Pl. LVII, figs. 4, 5, 6.

This is a rather large species of slightly transversely oval outline, moderately inflated valves, of which the ventral one is by far the flatter, and with an extremely broad median sinus in the dorsal valve.

The ventral valve is flat, obliquely conical, but very little arched in both directions. The apex is little prominent and barely at all bent over. The area is high and strongly reclining, but very little concave. The deltidial fissure is large, somewhat higher than it is broad, occupying just one-third of the entire area, which is very short in comparison to its height, the hingeline not being longer than half the transverse diameter of the shell. Immediately at the apex there begins a high and very broad median fold, which becomes so broad as to occupy the entire front of the shell. This fold is narrowly rounded on the top and in consequence somewhat roof-shaped. On each side of this median fold there is a lateral one, which is, however, low and little developed, although commencing also very near the apex of the valve. The remainder of the valve, up to the margins of the area, is smooth and gently vaulted. The fine radial striation is not very well visible on the outer surface of this species, owing to the somewhat coarsely silicified condition of the specimens.

The dorsal valve is very much more strongly vaulted than the ventral, and its inflation is about equal in both directions; it is also considerably larger than the ventral valve. The apex is enormously inflated and strongly bent over, and owing to a strong truncation it bears a large semi-circular foramen at its end, within which a small cardinal process is visible. The area is very small, nearly linear, and so strongly concave that it makes a nearly angular bend. In the immediate vicinity of the apex there commences the enormously broad and deep median sinus, which expands so as to occupy the whole frontal part of the valve. The sinus is bordered on both sides by narrowly rounded elevated ridges, which are followed laterally again by low folds, one on each side. The rest of the valve is smooth, sometimes perhaps with a very slight indication, near the margin, of a second lateral fold.

The internal characters could be well studied in one of the silicified specimens, and have been figured, Pl. LVII, figs. 5 and 6. In the ventral valve the three septa are very conspicuous features. The two lateral ones support the hinge-teeth, which are formed by the direct continuation of a thickened shelly ridge bordering the deltidial fissure; the median septum commences at the apex as a low shelly ridge, and ascends slowly to a high angular point, when it suddenly terminates (fig. 5*b*). The muscular impressions are probably situated between these septa, but they could not be observed.

In the dorsal valve the deltidial fissure is hemmed in by thick shelly ridges, which hang tolerably far down into the interior of the valve, making the same bend as is indicated by the concavity of the area. They do not, however, stop at the hinge-margin, but proceed far above it, expanding at the same time a little, and thus forming the curious kind of crura which imitate to a certain extent the shape of boars' tusks. Laterally, by their exterior side, these crura are fixed to strong diverging septa that originate near the apex of the valve and support the dental sockets, which latter are situated on the external side of the crura, where they project from the hinge-margin. In the middle of the apex an elongated ridge-like cardinal process is observable; lower down this cardinal process changes into a slightly elevated shelly line, which extends about as far as the lateral septa.

In this valve also the muscular impressions could not be distinguished.

The measurements of a specimen from Musakheyl are as follow:—

Entire length of the shell	34 mm.
Length of the ventral valve	29 „
Entire breadth of the shell	37 „
Length of the hingeline	19 „
Entire thickness of the shell	27 „
Height of the area of the ventral valve	8 „
Apical angle of the ventral valve	112°
„ „ „ dorsal valve	84°

Locality and geological position.—There are altogether five specimens of this species known to me, of which two were collected by Dr. Warth at Musakheyl in the upper region of the middle Productus-limestone, two were found by Mr. Wynne in the Chittawán in a similar geological position, and one specimen I brought myself from Virgal, where it occurred in the coral beds of the middle Productus-limestone.

Remarks.—This beautiful species is rather nearly related to the two previously described, but from both it can be easily distinguished by the peculiar configuration of its ventral valve, which is nearly quite flat, and has a beak that is not bent over, in consequence of which the area of that valve is scarcely at all concave. Other distinguishing characters are the scarcity of ribs and the enormously broad median sinus in the dorsal valve. From these characters it appears that the present form is an easily distinguishable species.

Of other species none can be compared particularly to the present one.

B.—Group of *ENTELETES PENTAMEROIDES*, W.

6. Enteletes pentameroides, Waagen, n. sp.; Pl. LVII, fig. 2.

This is the largest species of *Enteletes* that has been detected up to the present. The shell is about as long as it is broad, with extremely inflated valves, so as to be almost globular. Both valves are very strongly plicated.

The ventral valve is by far smaller than the dorsal one. It is very strongly arched, but more so in the longitudinal than in the transverse direction. The apex is well bent over, but it remains doubtful whether it is truncated or not. The area is high and very strongly reclining, flat for the greater extent along the hingeline, and strongly concave where the apex overhangs it. It is cut open in the middle by a large deltidial fissure. The hingeline is rather short. At a very little distance from the apex a median fold appears, which extends down to the front, but which is never very prominent or conspicuous. It is followed on each side by four lateral folds, which are not much less strong than the median one. They diminish in size the more they are removed from the median fold. The dorsal valve is very considerably larger than the ventral one, and chiefly the apical region projects far above the hingeline. Also the inflation is about twice as strong as that of the ventral valve; the curvature is, however, about equal in both directions. The apex of the valve is very strongly bent over, and almost entirely rolled in. It cannot therefore be exactly seen whether the apex is truncated or not. The area is very narrow and very strongly concave. A median sinus appears to commence directly at the apex and to extend down to the front line. It is neither very broad nor very deep, and not very distinct from the furrows which separate the other radial folds from each other. The sinus is shut in on both sides by rather high ridges, which are broadly rounded on the top and are more prominent than the remaining radial folds. These ridges are followed on each side by three to four radial plications, which gradually diminish in size, as they are moved from the median part of the valve.

Both valves are marked by concentric plications or striæ of growth, which are most strongly marked on the top of the radial folds, and are mostly restricted to the vicinity of the margins of the valves. The fine radial striation characteristic of the genus is less strongly marked in this species than in those previously described.

Of the internal characters of this species nothing is known to me.

The measurements of the only existing specimen are as follow:—

Entire length of the shell	39 mm.
Length of the ventral valve	30·5 „
Entire breadth of the shell	39 „
Length of the hingeline	24 „
Entire thickness of the shell	37 „
Height of the area of the ventral valve	8 „
Apical angle of the ventral valve	114°
„ „ „ dorsal valve	77°

Locality and geological position.—The only specimen of this species preserved in the Salt-range collection was found by myself in white, somewhat dolomitic, limestone forming part of the middle region of the middle Productus-limestone in the vicinity of Katwâhi.

Remarks.—This species is chiefly remarkable on account of a certain similarity it bears to *Enteletes lamarcki*, Fisch., from the upper carboniferous-limestone of Prussia, though the latter belongs to the section "Ventrisinuati" as indicated above. The excellent figures given by Trautschold in his memoir on the carboniferous-limestone of Mjatschkowa show in the middle of the ventral sinus an elevated fold, which originates at the apex of the ventral valve, whilst on the apex of the dorsal valve a sinus originates corresponding to the fold in the middle of the ventral sinus. If we now suppose that this median fold were to increase considerably in size, we should without much difficulty arrive at the figure as exhibited by *Ent. pentameroides*. It needs only a comparison of the figure, Pl. LVII, fig. 2*d*, of the present work, with that given by Trautschold in his monograph, Pl. VII, fig. 3*f*, to see how easily one form could have been changed into the other. Thus it becomes very probable that *Ent. lamarcki* is the ancestor of our *Ent. pentameroides*.

Of other species those described on the foregoing pages must be compared. The present form can be easily distinguished from all those by the much more prominent apical region and the narrower sinus of the dorsal valve and by the far stronger plication exhibited by both valves.

7. Enteletes acuteplicatus, Waagen, n. sp.; Pl. XLIX, fig. 10.

This species is considerably smaller than the preceding one, but otherwise not dissimilar. The general outline is considerably higher than broad, the dorsal valve being by far larger than the ventral one, and at the same time also much more inflated. Both valves are covered with very sharp and high radial folds.

The ventral valve is elevated conical, with a tolerably strong bend in both directions. The apex is pointed, not strongly bent over, and overhangs a large, nearly flat trangular area, which is so strongly reclining that it forms an acute angle with the plane of the valve. The deltidial fissure of the specimen is covered up by rock-matter. Immediately at the apex a median fold, which is high and angular, originates and extends down to the front. It is not much more prominent than the lateral folds which follow on each side. There are three to four of these folds on each side, which become gradually less prominent as they are more removed from the middle of the valve. The frontal margin of the valve forms a very strongly indented zig-zag line.

The dorsal valve is very much larger than the ventral one; it is also more strongly inflated, and therefore its curve is also more considerable in both directions. The apex is very much bent over and strongly inflated, the area below it very small and very concave. The deltidial fissure cannot be observed. At the apex there begins a deep and angular median sinus, which is, however, comparatively narrow.

On both sides of it narrow, angular, elevated ridges are situated, followed by three lateral folds diminishing gradually in size.

The radial striation of the shell is not preserved in this species, but the punctation can yet be seen in some places.

It is difficult to give measurements of the only existing specimen, as it is much deformed by pressure; so far as observable, they are as follow:—

Entire length of the shell, about	33 mm.
Length of the ventral valve	21 „
Entire breadth of the shell	29 „
Length of the hingeline	16 „
Entire thickness of the shell, about	23 „
Height of the area of the central valve	5 „
„ „ „ „ dorsal valve	3 „

Locality and geological position.—The only specimen of this species that is known to me was found by myself in the vicinity of Katwâhi in the upper division of the Productus-limestone.

Remarks.—The specimen upon which the present species is founded would not have been worth describing, its state of preservation is so bad, were it not that it represents the geologically youngest form of the genus *Enteletes* that has been observed up to the present. On account of this special interest, I have ventured to describe it under the above name. Even in its bad state of preservation the specimen can easily be recognised as representing a form very nearly related to *Ent. pentameroides*, W., but yet different from it. The differences consist chiefly in the strong and angular folds of both valves and in the more strongly reclining area of the ventral valve. The similarities on the contrary are to be sought for in the narrowness of the sinus in the dorsal and the little prominence of the median fold in the ventral valve.

From these circumstances it appears highly probable that though *Ent. pentameroides* may be the ancestor of *Ent. acuteplicatus*, yet the latter forms a well distinguishable separate species.

Sub-Family: *ORTHINÆ.*

Genus: *ORTHIS*, Dalm.

I accept this genus in the most restricted sense, as it has been circumscribed by Davidson and others, and think that it is most strictly characterised by the existence of two short crura in the dorsal valve. All the other forms formerly classed with *Orthis*, such as *Streptorhynchus*, *Orthisina*, &c., are entirely devoid of such crura, and instead of them the cardinal process, which is but little developed in *Orthis* proper, attains a development which already to a certain extent suggests the development of that part in the family *Productidæ*. I therefore not only exclude those forms from the genus *Orthis*, but altogether remove them from the family *Orthidæ*, uniting them at the same time with the family *Strophomenidæ*.

I have no new observation as to the internal structure of the Indian shells belonging to the genus, as the preservation of the materials is not propitious for such observations. Moreover, the species of *Orthis* are rather rare in the Salt-range; only at one locality, Amb, have many specimens of *Orthis* been found, in the lowest beds of the Productus-limestone.

Altogether seven species of *Orthis* have been detected in the Salt-range, assignable to three groups, differing in their internal arrangement. The first group is that of *Orthis morganiana*, Derby. This group forms a transitional link between *Orthis* proper and *Enteletes*. The interior structure of these forms has been very ably described by Mr. Derby. As in *Enteletes* there are two strong, curved up, horn-shaped crura, supported by strong diverging septa, in the dorsal valve, and three elevated ridges in the ventral one; but all these characters are much less strongly developed than in *Enteletes*, and chiefly the internal arrangement of the ventral valve approaches much nearer to that occurring in typical species of *Orthis* than to that of *Enteletes*. I thus think it more correct to retain these species in *Orthis* than to place them among the *Enteletes*. There are two species of this group in the Salt-range, which will bear respectively the name of *Orthis marmorea*, W., and *Orth. derbyi*, W.

For a second group the *Orthis resupinata*, Mart., is the type. The interior of the shells belonging to this group has been admirably described by Davidson. The differences from the preceding group consist chiefly in the less strong development of the crura and their shelly supports in the dorsal valve, and in the little development of the median ridge in the ventral one. This group is represented in the Salt-range also by two species, which will bear the names of *Orthis indica*, W. (= *Orth. resupinata*, Dav.), and *Orthis janiceps*, W.

The third group is typified by *Orthis michelini*, Lév. For the description and drawing of the interiors of the shells belonging to this group, we are again indebted to the admirable investigations of Mr. Davidson. The species of this group are chiefly different from those of the preceding one by the arrangement of their muscular impressions and by the interior character of the ventral valve. Whilst in *Orthis resupinata* and its allies there exists still a little developed median ridge in the ventral valve, this ridge is nearly quite absent in *Orth. michelini*. The species belonging to this group can also exteriorly be easily recognised by their elongated general outline and the extraordinarily short hinge-margin. This group is represented in the Salt-range by three species—*Orthis corallina*, W., *Orthis pecosii*, Marcou, and *Orthis incisiva*, W.

It cannot be denied that the three groups just indicated do not exactly correspond to what has been called generally in this work a "group;" these groups rather correspond to the "divisions" as introduced by me in other genera, or they might be even of sub-generic value. The reason why I called them simply groups is, that it is impossible for me to work up the whole host of species of *Orthis* existing in the devonian and silurian periods, partly on account of lack of materials, and partly on account of the impossibility to spend the necessary time on the subject;

but without a careful study including these older forms a definite sub-division of the genus cannot be arrived at. I thus did not like to prejudice by divisional or sub-generic names a future monographical treatment of the genus.

I.—Group (or Sub-division) of *ORTHIS MORGANIANA*, Derby.

1. Orthis derbyi, Waagen, n. sp.; Pl. LVI, figs. 2, 5, 6.

This species is of a middle size and does not seem to become large. Its general outline is nearly circular or transversely oval, the dorsal valve being considerably larger and more inflated than the ventral one. The latter valve bears a flat sinus in the middle.

The ventral valve is more or less conical, with a flat curve in the longitudinal and a very small curve in the transverse direction. The hingeline is very short; the area high, very strongly reclining, but very little concave and cut open in the middle by a very large triangular fissure, which is just as broad at its base as it is high. The area is tolerably sharply defined. The apex of the valve is very pointed, but very little bent over, and only slightly overhanging the deltidial fissure. Not far from the apex a median sinus begins, and extends down to the front, indenting the dorsal valve. The lateral parts of the valve are smooth.

The dorsal valve is much larger and more strongly inflated than the ventral one. Longitudinally its curve is much stronger in the apical than in the frontal region. Transversely the curve is strong but not equal; there is a kind of median carination of the valve observable extending from near the beak to the front, and on both sides of which the valve is somewhat flattened. The area is small, very sharply defined, and distinctly overhanging the area of the other valve. It is but little concave and cut open in the middle by a large triangular fissure. The apex of the valve is not complete, but truncated, whereby a kind of semi-circular foramen is formed, within which the small cardinal process is visible.

The surface of both valves is covered by strong imbricating striæ of growth, which form approximately a semi-circle in the ventral valve, but which are indented in passing over the median carination of the dorsal valve. The whole shell-surface is provided with a very fine radial striation, similar to that occurring in *Orthis resupinata*.

Of the interior characters of the species only those of the ventral valve are known to me, and these only partially. The specimen showing them is figured, Pl. LVI, fig. 2. The hinge-teeth are supported by very strong dental lamellæ, which are continued in the direction of the front as diverging, somewhat elevated, ridges up to a short distance from the front, then they suddenly bend round towards the middle and unite with a sharp but not very elevated median ridge, which latter does not, however, extend quite up to the apex of the valve. By these ridges two deep elongately oval grooves are circumscribed which evidently served for the insertion of the divaricator and adductor muscles, but the sub-division of these grooves cannot

be distinctly seen. A slight impression runs longitudinally about the middle of them, but I cannot be certain whether this indicates the limit between the two pairs of muscles. The whole apparatus has very much resemblance to the same apparatus in the ventral valve of *Orthis resupinata*, but is comparatively very much larger than in that species.

The measurements of two specimens, No. I from the middle Productus-limestone of the Chittawán, and No. II from the uppermost bed of the upper Productus-limestone of Virgal, are as follow :—

	I.	II.
Entire length of the shell	25 mm.	24 mm.
Length of the ventral valve	21 „	21·5 „
Entire breadth of the shell	26 „	27 „
Length of the hingeline	11 „	11 „
Entire thickness of both valves	18·5 „	17·5 „
Height of the area of the ventral valve . . .	4 „	5 „
„ „ „ „ dorsalvalve . . .	1·5 „	1 „
Apical angle of the ventral valve	109°	121°
„ „ „ dorsal valve	89°	96°

Locality and geological position.—There are altogether six specimens of this species known to me which range from the middle division to the topmost beds of the upper division of the Productus-limestone. Two specimens were found by Dr. Oldham and Mr. Wynne in the middle Productus-limestone of the Chittawán, and one specimen in the same division in the Bazárwán also by Mr. Wynne. By myself the species has been collected at Virgal in the coral-beds of the middle division of the Productus-limestone (two specimens), and one more specimen also at Virgal in the topmost beds of the upper division of the same formation.

Remarks.—This species is easily distinguishable from all the European forms of *Orthis*, to any of which it has not even a remote similarity. So much the more marked is its resemblance to the South American *Orthis morganiana*, Derby, from which, in fact, it is not quite easily distinguishable. Nevertheless there are some points of difference which prevented my uniting the Indian form specifically with the South American one. The chief differences consist in the smaller size, the comparative thickness of the shell, the obtusely carinated condition of the dorsal valve, the truncated beak of the same valve, and the imbricating striæ of growth which cover both valves in the Indian species. These differences seem to me perfectly sufficient for the specific distinction of the two forms.

I have called this species *Orthis derbyi* in honour of Prof. Derby, to whose excellent description of the Brachiopoda of Itaituba I owe much most valuable information.

2. Orthis marmorea, Waagen, n. sp.; Pl. LVI, figs. 3, 4.

The materials of this species are very scanty indeed, but still sufficient to characterise the shell as a new and well distinguishable form.

The general outline of the species is transversely oval or somewhat triangular, the greatest breadth being situated far down in the vicinity of the front. The dorsal valve seems to be larger than the ventral one, but I am not quite certain on the point, as I have only one isolated ventral valve for observation. The dorsal valve is not much inflated, and the ventral one even very flat.

The ventral valve is very little arched in both directions, and its curve is very regular. The apex is but little elevated, pointed, and little bent over. The hinge-line is rather short, the area not very high, triangular, flat, not at all concave, and but little reclining, forming an angle of 120° with the plane of the valve. It is cut open in the middle by a large triangular fissure, which is about as broad at its base as it is high. The surface of the valve is entirely smooth, without the slightest indication of a median sinus, and thus the frontal and lateral margins of the valve lie all in one plane, forming a gentle, and in the frontal region somewhat flattened, curve.

The internal characters of this valve can be beautifully observed in a specimen from the Bazárwán. The strongly developed cardinal teeth are situated on both sides of the triangular fissure, and are supported by oblique shelly septa, which are angularly cut out immediately at and below the teeth. They descend in a gentle curve down to near the front, becoming gradually lower, and then disappear. In the middle of the valve, beginning from the apex and being highest in the centre of the valve, a strongly elevated median septum is situated, very much resembling that in *Enteletes*, but in not quite so extreme a development. It suddenly decreases in height after having reached the centre of the valve, and then bifurcates; the bifurcating branches extend only for a short distance and then disappear without quite uniting with the termination of the two lateral septa. The arrangement of the muscular scars cannot be exactly traced.

The dorsal valve is more strongly vaulted than the ventral one, but nevertheless its inflation is not very considerable. It is regularly curved in both directions, and its apex is not more strongly inflated than the remainder of the valve. The apex is strongly bent over and well pointed. The area is narrow, very sharply defined, and strongly concave, cut open in the middle by a large deltidial fissure. The surface of the valve is entirely smooth, only very faint striæ of growth being observable. The margins of the valve, lateral as well as frontal, are all in one plane, an indentation of the front by the ventral valve being altogether absent.

Of the interior characters of this valve only the existence of two diverging septa, the shelly supports of the crura, can be traced. In extent and position these septa seem to be very similar to those that have been described in the genus *Enteletes*.

The surface in both valves is covered by a radial striation, which is so fine that it is scarcely possible to observe it with the naked eye. Between this striation tolerably numerous large roundish foramina are strewn irregularly over the whole shell. On them were probably situated fine hair-like spines.

The substance of the shell is rather thick and heavy.

The measurements of a dorsal valve from Virgal are as follow :—

Entire length of the valve	30	mm.
Length of the hingeline	18	„
Entire breadth of the valve	33	„
Entire thickness of the valve	14	„
Height of the area	3	„
Apical angle	110°	

A ventral valve from the Bazárwán, belonging to a somewhat smaller individual, exhibits the following dimensions :—

Entire length of the valve	25	mm.
Length of the hingeline	16	„
Entire breadth of the valve	29	„
„ thickness „ „	8	„
Height of the area	6	„
Apical angle	124°	

Locality and geological position.—There are altogether three specimens of this species known to me—two dorsal valves, one of which was collected by Dr. Oldham in the Chittawán, the other was found by myself in the coral-beds of Virgal; and one ventral valve brought by Mr. Wynne from the Bazárwán—all three specimens coming out of the hard, marbly, silicious limestones of the middle region of the middle Productus-limestone.

Remarks.—The species here under consideration is rather nearly related to the preceding *Orthis derbyi*, W., as well as to *Orthis morganiana*, Derb.

From the first it can easily be distinguished, by its much less inflated valves, the absence of a sinus in the ventral, and an indentation in the dorsal, valve, and by the absence of imbricating striæ of growth.

From the second it can be distinguished also by much less inflated valves, its heavy shell, and the absence of sinus and indentation in the ventral and dorsal valves.

II.—Group (or sub-division) of *ORTHIS RESUPINATA*, Mart.

3. Orthis indica, Waagen, n. sp.; Pl. LVI, figs. 7, 8, 14, 15, 16.

1862. *Orthis resupinata* (Mart.), Davidson : Quart. Journ. Geol. Soc., Lond., Vol. XVIII, p. 31, Pl. I., fig. 15.
1863. *Orthis resupinata* (Mart., Dav.), Koninck : Fossiles paléoz. de l'Inde, p. 37, Pl. X., fig. 15.

This species remains always very small; specimens of the size of the one figured by Davidson are the largest that have been observed up to the present.

The general outline of this species is mostly transversely oval, sometimes nearly circular, and rarely longer than it is broad. Of the two valves the ventral one is always the larger. The two valves are mostly about equally inflated. On the whole the species is, however, rather variable.

The ventral valve is the larger of the two. It is tolerably inflated, but its curve is not very regular, being rather inflated in the apical region and extending from there in a more flattened curve to the front. Transversely the curve is more regular. The beak is strongly incurved and pointed. It is bent over a small but tolerably high triangular area, which is strongly concave, and cut open in the middle by a moderately large deltidial fissure. The hingeline is short and not projecting on both sides. The surface of the valve is smooth, without a trace of a sinus or carination. The frontal margin is always strongly indented by the projecting frontal part of the dorsal valve.

The dorsal valve is always, but generally only very little, smaller than the ventral one; it is mostly also slightly more inflated. Longitudinally its curve is more regular than that of the other valve, but in the transverse direction it appears somewhat flattened in the middle, and then suddenly bends down to the lateral margins. The beak is strongly bent over and pointed. The area is small, very low, vertical and very sharply defined, cut open in the middle by a moderately large deltidial fissure. The valve is provided with a median sinus or impression which is mostly limited to the vicinity of the front in the specimens coming from the lower Productus-limestone, but reaches up to the apex in the specimens from the middle Productus-limestone. The frontral part of the valve projects a little and indents distinctly the corresponding part of the ventral valve.

On both sides slightly imbricating striæ of growth are to be observed. The fine radial striation which covers the whole shell is exactly like that in *Orthis resupinata*.

The interior structure of this species is altogether unknown to me.

The measurements of three specimens, No. I from the middle Productus-limestone of Katwáhi, and Nos. II and III from the lower Productus-limestone of Amb, are as follow :—

	I.	II.	III.
Entire length of the shell	18 mm.	15·25 mm.	14 mm.
Length of the dorsal valve	17·5 „	15 „	13·9 „
Entire breadth of the shell	20 „	16 „	13·75 „
Length of the hingeline	12 „	9 „	8 „
Entire thickness of the shell	14·5 „	12 „	12 „
Height of the area in the ventral valve	2 „	2 „	2 „
„ „ „ „ dorsal „	1·5 „	1 „	1 „
Apical angle of the ventral valve	108°	105°	90°
„ „ „ dorsal „	114°	112°	97°

Locality and geological position.—This species ranges through the lower and middle divisions of the Productus-limestone; in the upper division it has not been found up to the present. The greatest number of specimens was collected by me at Amb in the coaly sandstones at the very base of the Productus-limestone proper, above the lavender-clays (twenty-two specimens). In somewhat higher beds I found it at Katta, in the lowest strata of the compact limestones (one specimen). In the mountains east of Katwáhi, I detected the species in the middle region of the

compact limestones in a silicified condition (four specimens) and at Virgal in the coral-beds associated with *Orthis derbyi* and *Orth. marmorea* (one specimen). The geologically youngest exactly determinable specimen I collected near Khura in the upper region of the limestones forming the middle division of the Productus-limestone.

From the trans-Indus continuation of the Salt-range, one specimen was contained in Dr. Verchere's collection. It is preserved in a grey sandstone, but the exact locality where it came from is not known.

Remarks.—This species has been described by Mr. Davidson under the name of *Orthis resupinata*, Mart., but I think the forms from the Salt-range can be distinguished from Martin's species. Mr. Davidson had only two specimens at his disposal, and therefore could not state the constant recurrence of certain characters, which is very striking when a greater number of specimens is accessible for observation.

In the first place it is a remarkable fact that specimens of many sizes occur, but never larger than those figured by Davidson in the Quarterly Journal, and by myself in this work, Pl. LVI, fig. 8. The species evidently did not grow larger, and there is no conceivable reason why *Orthis indica* should always be of small size, whilst *Orthis derbyi* and *marmorea* should have grown in the same beds and at the same localities to considerable dimensions. We evidently have to deal here with a small form which never attained the dimensions of *Orthis resupinata*.

Another very characteristic feature consists in the circumstance that the dorsal valve *always* indents the ventral one, so that the front line bends down towards the ventral valve, instead of, as is the case in *Orthis resupinata*, being curved up towards the dorsal one. This seems the most essential point of difference between the two species, which chiefly led me to distinguish specifically between them.

Specimens of *Orthis resupinata* of a size equal to the largest specimens of *Orthis indica* have mostly less inflated valves, a more marked transversely oval general outline, and a frontline which is always more or less strongly bent up towards the dorsal valve. Even in specimens in which the dorsal valve is flattened or slightly impressed in the middle this curve upward is not entirely eliminated.

I therefore think that the Indian specimens can well be considered as forming a species different from *Orthis resupinata*, for which I introduce the name of *Orthis indica*, W.

4. Orthis janiceps, Waagen, n. sp.; Pl. LVI, fig. 9.

The species which I describe under the above name is about of the same size and general appearance as the preceding one, but can be distinguished on a close examination by the existence of a sinus in both valves, and by the dorsal valve being larger than the ventral one.

The general outline is transversely oval, with moderately inflated valves, of which the dorsal one is deeper.

The ventral valve is tolerably elevated in the apical region, but its curve is rather unequal. Longitudinally the curve is pretty strong in the vicinity of the

apex, and flattens considerably towards the front. In the transverse direction, however, the curve is rather regular. The apex is pointed and strongly bent over. The area is comparatively large, distinctly concave, and very strongly reclining, cut open in the middle by a not very large deltidial fissure. From near the apex there extends a flat, little impressed sinus along the middle of the valve down to the front. This valve is very slightly indented in the frontal region by the dorsal valve.

The dorsal valve is more strongly inflated than the ventral one, and also slightly larger. The longitudinal curve is very strong in the apical region and considerably flattened towards the front. Transversely the curve is somewhat flattened in the middle and strongly bent down on the lateral parts. The apex is much inflated, considerably bent over and pointed. The area is distinctly defined and very narrow, cut open in the middle by a very large deltidial fissure. Very near the apex there begins a longitudinal median sinus, which is more strongly impressed and broader than that of the other valve. The frontal part of the valve projects a little, causing a slight indentation of the same part of the opposite valve.

The interior characters of this species are not known to me.

The fine radial striation which covers both valves is exactly like that occurring in *Orthis resupinata*.

The measurements of a specimen from Katwáhi are as follow :—

Entire length of the shell	15 mm.
Length of the ventral valve	14·5 „
Entire breadth of the shell	17·5 „
Length of the hinge-line	8 „
Entire thickness of the shell	11 „
Height of the area of the ventral valve	2 „
„ „ „ dorsal „	1 „
Apical angle of the ventral valve	108°
„ „ dorsal „	105°

Locality and geological position.—There are only two specimens of this species preserved in the Salt-range collection, which were both found by myself in the mountains east of Katwáhi in the middle region of the middle Productus-limestone together with *Orthis indica*, W., described before.

Remarks.—The two specimens by which the species is represented are not easily distinguishable from the very similar *Orthis indica*, and it was only after a careful study and comparison that I came to distinguish between the two forms. It is true the sinus in both valves is an easily observable feature, but if this were the only means by which the present form were distinguishable from *Orthis indica*, it would be very doubtful whether a specific distinction between the two forms could be advocated. Only after I had detected another peculiarity, which consists in the ventral valve being the smaller one, in opposition to the characters occurring in *Orthis indica*, I became certain that a specific distinction between the two forms was necessary.

I thus have introduced the name of *Orthis janiceps* for the form here under consideration.

III.—Group (or Sub-division) of *ORTHIS MICHELINI* (Lév.).

5. Orthis corallina, Waagen, n. sp.; Pl. LVI, fig. 1.

The general outline of this species is nearly circular, very little broader than it is long, with the ventral valve nearly flat and the dorsal one only very little curved.

The ventral valve is but very little curved in every direction, and even the apical region is not at all inflated. The beak is thin and pointed, barely at all incurved, and very little projecting above the apex of the dorsal valve. The area is very small, and the hinge-line extremely short. The deltidial fissure is not distinctly visible, being for the greater part concealed by rock. The valve is smooth for the greater part, only in the frontal region a very faint impression takes place, causing the front-line to ascend a little.

The dorsal valve is very little smaller than the ventral one, but more strongly curved in every direction. The curve is rather flat in the longitudinal, and somewhat more strongly elevated in the transverse direction. The apex is little prominent, thin, pointed, and not much bent over. The valve is smooth for its whole extent, neither carinated nor impressed in the middle.

Both valves are extremely thick and heavy. They are covered by a fine radial striation, similar to that occurring in *Orthis michelini*.

The interior structure of this species is wholly unknown to me.

The measurements of the only existing specimen are as follow :—

Entire length of the shell	25 mm.
Length of the dorsal valve	24·5 „
Entire breadth of the shell	26 „
Length of the hinge-line	7 „
Entire thickness of the shell	12 „
Apical angle of the ventral valve	113°
„ „ „ dorsal „	130°

Locality and geological position.—The only specimen of this species that is known up to the present was collected by myself at Virgal in the coral-beds of the middle Productus-limestone.

Remarks.—On a first glance this species seems to be very similar to *Orthis michelini*, Lév., but on a closer examination one finds soon that only the group characters are identical, whilst the specific characters are decidedly different. The difference is chiefly striking in the general outline. This is always trapezoidal or more or less transversely oval in *Orthis michelini*, whilst the Indian form is nearly circular. This difference of outline is chiefly caused by the extreme shortness of the hinge-line and the nearly entire absence of an area in the ventral valve of *Orthis corallina*. Moreover, the Indian shell has extremely thick and heavy valves—a circumstance which is never the case, so far as I am aware, in *Orthis michelini*. Thus I think two forms can be well distinguished specifically.

Another form that must be compared to the present species is the one figured by Kayser from Lo-Ping in China under the name of *Orthis pecosii*, Marcou. This form is different from the Indian species by much more inflated valves and a much larger apical angle, which causes the shell to assume a more or less rectangular general outline. Thus also from this form the Indian shell can well be distinguished.

6. Orthis pecosii, Marcou; Pl. LVI, fig. 13.

1858. *Orthis pecosii*, Marcou: Geology of North America, p. 48, pl. VI., figs. 14 *a*, *b*.
1858. *Orthis carbonaria*, Swallow: Transact. Acad. Scienc., St. Louis, I., p. 218.
1872. *Orthis carbonaria* (Swallow), Meek: Final report on Nebrasca, p. 173, Pl. I. figs., 8 *a*, *b*, *c*.

The small specimen which serves for description belongs decidedly to the group of *O. michelini*.

The general outline is elongately roundish triangular, with strongly prominent not much unequal beaks and flattened valves.

The ventral valve is very little arched, but more so in the apical than in the frontal region, its curve being rather strong near the apex and very much flattened towards the front. Also in the transverse direction the curve is more strong in the middle and flattened towards the margins. The apex is well bent over and pointed, provided below with a very small area, which is, however, nearly all covered up by the apex of the other valve, as the ventral valve extends only little in excess of the dorsal one. The hinge-line is short, not projecting on both sides as has been erroneously drawn in the enlarged figure on Pl. LVI.

The dorsal valve is very little smaller than the ventral one, but it is more strongly inflated. Its curve is very strong in the apical region, but flattens all round towards the margins. The apex is strongly bent over, and concealed below the apex of the other valve. The hinge-line is very short, and the area of this valve cannot be seen at all.

Both valves are entirely smooth with the exception of some imbricating striæ of growth, and the fine radial striation characteristic of the species belonging to the group of *Orthis michelini*. The large perforations left by the removal of small tubular spines, which also occur on all these species, are, however, rather exceptionally numerous towards the margins of both valves in this species.

Of the interior characters of this species nothing is known to me.

The measurements of the only existing specimen are as follow:—

Entire length of the shell	11 mm.
Length of the dorsal valve	10 „
Entire breadth of the shell	10·5 „
Length of the hinge-line	4·5 „
Entire thickness of the shell	5·5 „
Apical angle of the ventral valve	91°
„ „ „ dorsal „	113°

Locality and geological position.—The only specimen of this species that has been found up to the present in the Salt-range was collected by myself at Amb in the so-called *Chonetes* bed of the lower division of the Productus-limestone.

Remarks.—I think there can be but little doubt that the specimen here described belongs to Marcou's species. The size as well as all the other characters are perfectly identical, and it would be rather difficult for me to indicate points of difference between the Indian and the American specimens.

In America, however, it seems that different things have been placed under the name; and especially the large form figured by Meek from California, I should not like to include in this species. So am I also doubtful whether the rather large and square specimen figured by Kayser from Lo-Ping in China can be assigned to Marcou's species.

Orthis pecosii is, in America, a characteristic species of the upper coal-measures.

7. Orthis incisiva, Waagen, n. sp.; Pl. LVI., figs. 10, 11, 12.

The general outline of this species is elongately triangular with rounded corners. The valves are not much inflated and very little different in size, the dorsal one being smaller.

The ventral valve is slightly larger than the dorsal one and not at all inflated. Its curve is very unequal; longitudinally it is tolerably strongly vaulted in the apical region, but very soon the curve becomes flat, forming almost a plane down to the front-line. In the transverse direction the curve ascends rather rapidly from the margins of the valve, but is then suddenly strongly depressed. The remarkable flattening of the valve thus produced, without forming quite a sinus, is a very characteristic feature of the species. The apex is well bent over, pointed, and rather strongly prominent. The area is small, high, and strongly reclining, covered for the greater part by the apex of the other valve. The deltidial fissure cannot be observed. The front-line is entirely straight, or sometimes very slightly bent up towards the dorsal valve.

The dorsal valve is a little smaller than the ventral one, but much more strongly inflated. Its curve is at the same time more regular. Longitudinally the curve is very strong in the apical region, and somewhat flattened towards the front. In the transverse direction the curve is equal throughout. The apex is very strongly bent over and partly disappears within the deltidial fissure of the other valve, in consequence of which the area of this dorsal valve is entirely concealed.

On both valves of this species some faint, slightly imbricating striæ of growth are observable. The fine radial striation, characteristic of all these shells, is not very well preserved on all the specimens I have for description. The substance of both valves is comparatively very thick and heavy.

The interior characters of this species are entirely unknown to me.

The measurements of two specimens, one complete, the other only a ventral valve, are as follow:—

	I.	II.
Entire length of the shell	9 mm.	15 mm.
Length of the dorsal valve	8·5 „	...
Entire breadth of the shell	8·5 „	13 „
Length of the hinge-line	3 „	5 „
Entire thickness of the shell	5·5 „	...
Thickness of the ventral valve	2·5 „	4 „
„ „ „ dorsal „	3 „	...
Height of the area of the ventral valve	1·5 „	2 „
Apical angle of the ventral valve	75°	77°
„ „ „ dorsal „	100°	...

The specimen No. II is the largest that has been observed up to the present, and I doubt whether the species ever grew much larger.

Locality and geological position.—There have altogether five specimens of this species been found up to the present. All five were collected by myself near Amb in the lowest beds of the compact limestones which form the middle division of the Productus-limestone.

Remarks.—The general outline of this species is so very remarkable that its form cannot easily be mistaken. Of all the species of *Orthis*, this one has the smallest apical angle and the most strongly triangular shape. Nevertheless I think it cannot be doubted that the species forms part of the group of *Orthis michelini*. The very little inflated valves, the very approximated beaks of the valves, the short hinge-line, characters among the most striking of the group, this species possesses in common with *Orthis michelini*.

The species scarcely needs a closer comparison with any other form except with *Orthis pecosii*, Marcou. This American form also has a somewhat triangular outline and very little inflated valves; the beaks are very much approximated and tolerably prominent, but in all these characters *Orthis incisiva* is much more extreme than the American species, and besides this the peculiar flattening of the ventral valve is a character which does not occur in *Orthis pecosii*.

Family: *STROPHOMENIDÆ*.

In this family we find for the first time the type of the *Aphaneropegmata* fully developed. As has been stated above, *Orthis* and its allies are still provided with rudimentary crura in the dorsal valve, and might perhaps, together with the family *Rhynchonellidæ*, form a proper distinct sub-order, from which the others have taken their origin. In the *Strophomenidæ*, on the contrary, even rudiments of crura are entirely absent, and the most striking characters can only be derived from the different development of the cardinal process of the dorsal valve,—an organ that is of the greatest importance for the systematic arrangement of these shells. Nevertheless, this organ does not seem to replace the loop and crura of other Brachiopo ds

the parts to which the brachial appendages were fixed must be looked for elsewhere. Most recently Prof. Neumayr has published a short notice, in which he demonstrates the occurrence of reniform impressions also in *Strophomena*, and expresses the opinion that these reniform ridges were the organs to which the labial appendages had been fixed. We shall have occasion to recur to this opinion in describing the *Productidæ*, where reniform impressions are of far more general occurrence than in the *Strophomenidæ*.

The *Strophomenidæ* may be very conveniently divided into four sub-families, which can chiefly be distinguished by the different development of the cardinal process.

The first sub-family that I am able to distinguish is the ORTHISINÆ, to which only one genus, ORTHISINA, Orb. (*Hemipronites*, *Klitambonites*, &c., Pander), belongs. This genus is still very nearly related to *Orthis;* the cardinal process is very small, but every indication of crura, even only rudimentary, is absent. It forms by itself a very easily distinguishable group of the *Strophomenidæ*.

The second sub-family will have to bear the name of ORTHOTHETINÆ, and will comprise four genera, all provided with a strong cardinal process, which is mostly supported by two septa partly surrounding the muscular impressions. These genera are:—

1. TRIPLESIA, Hall, 1859 (12th Reg. Rep., New York State Cab., p. 44, figs. 1—3), Davidson: Suppl. Brit. Sil. Brach., p. 141. The strange bifid cardinal process shows very clearly that this shell belongs to the *Orthothetinæ*, and not to the *Rhynchonellidæ* in which it has been placed by others.

2. STREPTORHYNCHUS, King, 1850: Monogr. Brit. Perm. Foss., p. 109. The cardinal process is large, supported by two septa, which partly surround the muscular impressions. The ventral valve is devoid of a median septum; permian.

3. DERBYIA, Waagen, n. gen. The cardinal process is very similar to that of the preceding genus, but in the ventral valve a strong median septum is present; carboniferous to permian.

4. MEEKELLA, White and St. John, 1856: Transact. Chicago Acad. Sci. I, p. 120, figs. 4—6. The cardinal process is similar to that in the preceding genera. In the ventral valve the hinge-teeth are supported by strong dental plates, which form two septa. A median ventral septum is absent; mountain-limestone (*Meek. olivieriana*, Vern.) to coal-measures (*Meek. eximia*, Eichw.; *Meek. striato-costata*, Cox).

5. ORTHOTHETES, Fischer von Waldheim, 1830: Oryctogr. du Gouv. de Moscou, p. 133, Pl. XX, fig. 4. Cardinal process small and not supported by septa, a little developed median dorsal septum mostly present; the ventral valve without a septum; devonian to (?) permian.

The third sub-family will bear the name of STROPHOMENINÆ. The forms belonging to this sub-family have the cardinal process mostly very small and always bifid, and the two valves leave very little space between them. The genera which I consider as belonging to this sub-family are the following:—

1. STROPHOMENA, Blainville, 1825, emend. Davidson.

2. STROPHODONTA, Hall, 1850: Proc. Am. Assoc., 1850, p. 348.

3. LEPTAGONIA, M'Coy, 1844: Synops. Carb. Foss. Ireland, p. 116, emend. Zittel: Handb. 678.

4. LEPTÆNA, Dalman, 1828, emend. Davidson.

It is not necessary to add here any particulars about these genera, as they are mostly already well known from Davidson's admirable works.

There remains, however, one group which probably forms part of the family *Strophomenidæ;* it is typified by the genus *Amphiclina*, Laube, which probably must be considered as the prototype of a fourth sub-family, for which I shall introduce the name of AMPHICLININÆ. To this sub-family the genus *Aulacorhynchus*, Dittmar, will probably also be assigned.

Of these four sub-families the first is of an exclusively silurian and devonian distribution. The second commences already in the silurian period and extends thence up into permian beds, perhaps even to still more recent formations. The third is also most numerously represented in the silurian and devonian epochs, and ascends only in isolated forms into carboniferous strata. The fourth at last occurs in carboniferous and triassic beds.

In the Salt-range only the *Orthothetinæ* and the *Strophomeninæ* are represented. Of the *Orthothetinæ* three of the genera included by me in the sub-family occur in the Salt-range, and there are of the genus *Streptorhynchus* seven and of the genus *Derbyia* six species present; the genus *Orthothetes* has furnished only a single species. It then appears that the sub-family is altogether represented by fourteen species. Of the sub-family *Strophomeninæ* there has up to the present been detected only a single somewhat doubtful species of *Leptæna*. It is a fact worthy of notice that the genus *Leptagonia*, which is of not rare occurrence in the carboniferous deposits of England and elsewhere, is entirely absent in the Salt-range.

Sub-family: *ORTHOTHETINÆ*, W.

Genus: STREPTORHYNCHUS, King.

It has given me very great trouble to find out what name this genus ought to bear, and even now I am somewhat in doubt on the matter, as still the possibility remains of its being identical with *Hipparionix*, but the true *Hipparionix* seems to possess dental plates, which are decidedly absent in *Streptorhynchus*. I have therefore returned to King's name *Streptorhynchus*, of which the signification is quite certain.

If we take the characters of the typical species, *Strept. pelargonatus*, to be those of the genus, we find that in the ventral valve the more or less high area is interrupted in the middle by a strong pseudodeltidium, which is always entirely closed. The hinge-line is generally not quite so long as the greatest breadth of the shell. On both sides of the termination of the pseudodeltidium tolerably strong hinge-teeth are situated, which are prolonged inside the area in prominent ridges

that accompany the pseudodeltidium. Any kind of septum in the ventral valve is entirely absent.

In the dorsal valve a large cardinal process is present, which is erect and reaches far into the cavity of the ventral valve. The process is bifid, bearing on its upper (dorsal) side a longitudinally in-cut line. On both sides of the process the dental sockets are placed and supported by short diverging septa, which partly surround the muscular impressions. In the dorsal valve the two pairs of adductor scars cannot well be distinguished, as they are not distinctly separated from each other, only between the right and left groups of impressions a distinct rounded ridge extends. In the ventral valve the muscular scars make also two groups of elongately oval impressions, separated from each other by a low rounded ridge; but also here the distinction of the scars of the cardinal and adductor muscles is difficult.

The characters by which this genus may most easily be distinguished are—the presence of two diverging septa in the dorsal valve and the absence of a median longitudinal septum in the ventral valve.

This genus is rather largely represented in the Salt-range, and there can be distinguished two large groups of forms, of which one has smooth and the other radially plicated valves. The first section I shall call "*Simplices*," and the second "*Plicati*." The second group exhibits a very great resemblance to the genus *Meekella*, White and St. John, and in fact I am very doubtful whether this genus ought not for the most part to be merged in the genus *Streptorhynchus*. Meek in the "Final report on Nebrasca" gives a woodcut of *Meekella striatocostata*, in which he draws two strong septa, representing the dental plates, in the ventral valve. These septa certainly exist in some forms, but with them in Nebrasca there also occur shells which are devoid of septa, as I have seen a specimen in the Royal Palæontological Museum in Munich in which these septa seem to be absent. Thus also in America the *Plicati* forms of the genus *Streptorhynchus* seem to occur, and this shows clearly that the plication alone cannot serve for the distinction of the genus *Meekella*. The absence of septa in the Indian shells has been pointed out already by Meek.

The first section, the *Simplices*, is represented in the Salt-range by four species, which can be separated into two groups. The first of these is typified by *Strept. pelargonatus*, Schloth., and is represented in the Salt-range by *Strept. pelargonatus*, Schl., and *Strept. lenticularis*, W. The second group comprises only forms that are restricted to the Salt-range. It will be called group of *Strept. capuloides*, W., and will contain the species *Strept. capuloides*, W., and *Strept. operculatus*, W.

The second section, the *Plicati*, is represented in the Salt-range by three species, which can again be brought into two groups, the first of which will have to bear the name of a group of *Strept. hallianus*, Derb., with only one species, *Strept. deltoidens*, W., and the second group will be called the "group of *Strept. pectiniformis*, Dav.," with two species, *Strept. pectiniformis*, Dav., and *Strept. distortus*, W.

We have thus arrived at the following grouping of the species:—

I.—Section Simplices.

a.—Group of Strept. pelargonatus, Schloth.
1.—*Strept. pelargonatus*, Schl.
2.— „ *lenticularis*, W.

b.—Group of Strept. capuloides, W.
3.—*Strept. capuloides*, W.
4.— „ *operculatus*, W.

II.—Section Plicati.

c.—Group of Strept. hallianus, Derby.
5.—*Strept. deltoidens*, W.

d.—Group of Strept. pectiniformis, Dav.
6.—*Strept. pectiniformis*, Dav.
7.— „ *distortus*, W.

The genus seems in Europe to be restricted to the permian period, though perhaps some forms that occur in the mountain-limestone might also belong to it.

In the Salt-range the different species are distributed through the whole mass of the Productus-limestone, from the lowest to the topmost beds. The first section, the *Simplices*, is restricted to the lower and middle divisions, whilst the second section, the *Plicati*, chiefly occurs in the upper division.

Of all the seven species occurring in the Salt-range only one is identical with a European species; this is, *Strept. pelargonatus*, the well-known typical permian form. It is the typical form that occurs in the Salt-range, and not the one that has been called by Möller *Strept. pelargonatus*, and which belongs to the genus *Derbyia*. The occurrence of this form in India is of importance, as it again augments by one the number of permian species that are represented in the Salt-range.

I.—Section: SIMPLICES.

a.—Group of *STREPTORHYNCHUS PELARGONATUS*, Schloth.

1. Streptorhynchus pelargonatus, Schloth. sp.; Pl. L, figs. 3, 4, 5, 7.

1816. *Terebratulites pelargonatus*, Schlotheim: Denkschr. d. K. Acad. d. W. in München, Vol. VI, p. 28, Pl. VIII, figs. 21—24.
1837. *Orthis laspii*, Buch.. Über Delthyris, p. 62.
1848. *Orthis pelargonata* (Schl.), Geinitz: Deutsch. Zechst., p. 13, Pl. 5, figs. 11—15.
1850. *Streptorhynchus pelargonatus* (Schloth., sp.), King: Monogr. Perm. Foss., 108, Pl. X, figs. 18—28.
1858. *Streptorhynchus pelargonatus* (Schloth. sp.), Davidson: Monogr. Brit. Perm. Brach., p. 32, Pl. II, figs. 32—42.
1861. *Orthis pelargonata* (Schloth. sp.), Geinitz: Dyas, Vol. I, p. 92, Pl. XVI, figs. 26—34.
1871. *Orthis pelargonata* (Schloth.), Quenstedt.: Petref. Deutschl., Brachiop., p. 548, Pl. 55, figs. 51—56.
1880. *Streptorhynchus pelargonatus* (Schloth. sp.), Davidson: Suppl. Brit. Perm. Brach., p. 243, Pl. XXX, fig. 3.

The most instructive figures of this well-known species have been published by Geinitz and Davidson, and with these figures the Indian specimens agree in every detail.

This species never attains any considerable dimensions; and this is not caused, as might be supposed, by the supposition that it always forms part of a generally dwarfed fauna, for also in India it occurs always in small specimens, though it has lived there associated with truly gigantic shells, such as *Derbyia grandis*, which will be described later on in this work.

The general outline is extremely variable, and it is barely possible to give any positive general description of it. The ventral valve bears always a very large area, in consequence of which this valve is considerably larger than the dorsal one. The latter has always a slight median impression. The hinge-line is always shorter than the greatest breadth of the shell.

The ventral valve is generally longer than it is wide; only rarely is the contrary the case. The beak is not much pointed and barely at all bent over, but is twisted in various directions. The area is very large, vertical or somewhat reclining, provided in the middle with a not very broad vaulted pseudodeltidium. The depth and curvature of the valve are again very variable, but generally the ventral valve is deeper than the dorsal one. Sometimes the ventral valve bears an obtuse longitudinal median carination, sometimes not; but the frontal line always bends down to the ventral side, the ventral valve being indented by the dorsal one.

The dorsal valve is always considerably broader than it is long. It is always somewhat flattened, its curvature being never very considerable; it is, however, more strongly bent in the longitudinal than in the transverse direction. In the middle of this valve there is always a more or less strongly developed median impression which causes the front-line to descend considerably towards the ventral side. The area of this valve is mostly linear, and the apex but very little prominent.

Of the internal characters of this species nothing can be stated from the Indian specimens except the absence of a median septum in the ventral valve.

Both valves are covered by a fine radial striation, which augments towards the margins of the valves by intercalation of new ribs. This radial striation is crossed by strong imbricating striæ of growth.

The measurements of two specimens from Katta are as follow :—

	I.	II.
Entire length of the shell	20 mm.	15 mm.
Length of the dorsal valve	13 „	11 „
Entire breadth of the valve	13·5 „	13 „
Length of the hinge-line	11 „	9 „
Thickness of both valves	12 „	8 „
Apical angle of the ventral valve	65°	75°

Locality and geological position.—This species is not very rare in certain beds at certain localities of the Salt-range. The greatest number (3 specimens) I collected

at Katta in the lowest beds of the compact limestones forming the middle division of the Productus-limestone (bed No. 12 of my note-book) within a few minutes during a rapid visit to the locality. Another specimen I found at Amb in the coaly sandstones forming the lowest fossiliferous beds of the Productus-limestone above the lavender-clays.

Remarks.—There cannot, it seems, be the slightest doubt that the Indian specimens represent the typical form, which was called originally by Schlotheim *Terebratulites pelargonatus*, and which is so very characteristic of the Zechstein and the magnesian-limestone of Europe. It needs only a comparison of the drawings published by Geinitz, chiefly the specimens represented in figs. 26 and 31 of Pl. XVI. of his work, to make the identity of those forms with the ones drawn on our Pl. L immediately apparent.

Something quite different from the Indian shells are, however, those fossils which have been called by Möller *Strept. pelargonatus*, and which were originally described by Abich under the names of *Strept. perigrinus* and *Strept. crenistria*, from permian beds of Armenia. We shall see later on that these form part of the genus *Derbyia*.

The occurrence of the typical form of *Strept. pelargonatus* in the Salt-range is of the greatest geological importance, as this form augments again by one the already considerable number of permian species occurring there.

2. Streptorhynchus lenticularis, Waagen, n. sp.; Pl. L, fig. 8.

This is also a small species, which is characterised by its transversely oval outline, its small strongly reclining area in the ventral valve, and the general lenticular shape of the whole shell.

The ventral valve is flat, conical, not much vaulted in any direction. The curvature is, however, not quite regular; it is very slight in the longitudinal direction, and much stronger transversely, a barely perceptible broad obtuse ridge extending from the apex to the front, on both sides of which the valve is somewhat flattened. The apex is well pointed, prominent but not at all bent over; the area comparatively not very large, flat and rather strongly reclining, in the middle interrupted by a narrow convex pseudodeltidium. The hinge-line is very short.

The dorsal valve is considerably shorter than the ventral one. It is tolerably strongly inflated in the apical region, but otherwise it is rather flat. Its curvature is stronger in the longitudinal than in the transverse direction. The apex is slightly prominent and well bent over, the area only linear. From the apex down to the front there extends a broad but rather flat median sinus, which causes the front-line to descend in the direction of the ventral valve, and thus the dorsal valve indents the ventral one.

Both valves are covered by a fine but sharp radial striation which augments towards the margins of the valves by intercalation of new ribs. Besides this striation there are strong imbricating striæ of growth.

The internal characters of this species are not known to me.

The measurements of the only existing specimen are as follow:—

Entire length of the shell	20 mm.
Length of the dorsal valve	18 „
Entire breadth of the shell	21·5 „
Length of the hinge-line	12 „
Entire thickness of the shell	12 „
Apical angle of the ventral valve	98°

Locality and geological position.—The only specimen of this species that has been detected up to the present was found by myself at Katta, in the lowest beds of the compact limestones that form the middle division of the Productus-limestone (bed No. 12 of my note-book).

Remarks.—This species is very nearly related to *Strept. pelargonatus* with which it occurs in the same bed, and many authors would probably not have separated it from that species. I think, however, that the much more regular general configuration of the whole shell, the smaller and more strongly reclining area and the marked lenticular shape, may serve for a specific distinction. So much is certain, that the form here under consideration does not present the features of the typical *Strept. pelargonatus*, and already for this reason it seems desirable not to mix up this form with the typical one.

The species here under consideration seems to be much rarer than the typical *Strept. pelargonatus*.

b.—Group of *STREPTORHYNCHUS CAPULOIDES*, W.

3. Streptorhynchus capuloides, Waagen, n. sp.; Pl. L, fig. 9.

Shell small, nearly globular, with strongly inflated valves, the ventral valve being slightly shorter than the dorsal one. The hinge-line shorter than the greatest breadth of the shell.

The ventral valve is depressed, conical, patelliform, the area being so large and so strongly reclining that the apex is shifted towards the centre of the valve. The curvature is very strong in the transverse direction, but barely perceptible longitudinally. The apex is pointed and not at all bent over; the area entirely flat, forming an equilateral triangle. In the middle of it extends a very narrow, vaulted pseudodeltidium, which bears a slight longitudinal impression on the top. The whole valve is regularly vaulted without any crest or median fold, though the front-line is slightly indented. Only along the crests that mark off the area there extend slight impressions from the apex to the terminations of the hinge-line, so that this line at both ends projects in little wings.

The dorsal valve is slightly larger than the ventral one. It is strongly inflated, chiefly in the apical region, but its curve is rather equal in both directions.

The apex is not prominent, but strongly bent over. There exists a very narrow but distinct area in this valve, which is not quite one millimeter broad, and

extends all along the hinge-line. In the middle it seems to be interrupted for the passage of the cardinal process. About half way from the apex there commences a broad but very shallow median sinus, which extends down to the front and slightly indents the ventral valve. Both ends of the hinge-line are slightly prominent, forming small indistinct wings.

Both valves are covered by a fine radial striation, but the concentric striæ of growth are not conspicuous.

Of the internal characters of this species nothing is known to me, except that a ventral median septum is absent.

The measurements of the only existing specimen are as follow :—

Entire length of the shell	16·5 mm.
Length of the dorsal valve	15 „
Entire breadth of the shell	18 „
Length of the hinge-line	11 „
Entire thickness of the shell	14 „
Height of the area in the ventral valve	9 „
Apical angle of the ventral valve	70°

Locality and geological position.—There is only a single specimen of this species known up to the present. It was collected by myself at Nursing-Pohár in black coaly calcareous beds, at the base of the limestones forming the middle division of the Productus-limestone, together with *Dielasma itaitubense*, Derb., &c.

Remarks.—The general configuration of this species is very peculiar, and not at all similar to that of other species of *Streptorhynchus*, and I was for a long time inclined to consider it as belonging to the genus *Orthisina*. There is, however, not a trace of a foramen to be detected in the ventral valve, and the species also shows a certain typical similarity to *Strept. pelargonatus* as well as to the species which will be described next; and from these indications I have decided to place the species in the genus *Streptorhynchus*, though the internal characters of it are not known.

From *Strept. pelargonatus* the species is easily distinguishable by its inflated valves and by the shortness of the ventral one, caused by the large and extremely reclining flat area.

Of other species none can be compared more particularly to the present one.

4. Streptorhynchus operculatus, Waagen, n. sp.; Pl. L, fig. 6.

This is again a very small species, of a semi-conical general form, the ventral valve being pyramidal or conical, and the dorsal valve resting on the other like an operculum. From this configuration, the shell assumes very much the appearance of a small *Caprina*, the similarity being augmented by the fine radial striation with which both valves are covered.

The ventral valve, as has been already stated, is elevated conical, with one vertical and one sloping side. The vertical side is occupied by the large area. The apex of this valve is not quite complete in the specimen that serves for description; it seems to have been not pointed but rather rounded, and not at all bent over. The area is very high, just as high as it is wide, forming an isosceles triangle, of which the hinge-line represents the short side; it is flat and concave and bears in the middle a narrow vaulted pseudodeltidium, which extends from the apex to the hinge-line. Except the area, the valve is very regularly rounded, and bears neither a median fold nor a median sinus. The front-line is nearly straight, only very lightly indenting this valve.

The dorsal valve is strongly inflated, chiefly in the apical region. Its curve is equally strong in both directions, but longitudinally the bend is stronger in the apical than in the frontal region. The hinge-line is very short, the area not quite linear, though very narrow. The apex is strongly bent over, but not prominent. There is only a slight trace of a median sinus observable; it commences at a short distance from the apex, and extends down to the front.

The surfaces of both valves are covered by a radial striation which is finer than in other species of *Streptorhynchus*. It is very similar to that occurring in many species of *Orthis*, but this apparent fineness of the striation may be partly due to the mode of preservation of this species, the surface of both valves being much corroded and otherwise obliterated by weathering.

The internal structure of this species is not known to me. The only point I could ascertain with certainty was the absence of a median septum in the ventral valve.

The measurements of the only existing specimen are as follow:—

Length of the dorsal valve	15 mm.
„ „ „ ventral „	15·5 „
Entire breadth of the shell	15·5 „
Length of the hinge-line	8·5 „
Entire thickness of the shell	16 „
Height of the area of the ventral valve	8·5 „
Apical angle of the ventral valve	70°

Locality and geological position.—The only specimen that has been detected up to the present was found by Dr. Oldham in the Bazárwán, in the middle Productus-limestone.

Remarks.—This species is so peculiar in its general configuration that it cannot easily be mistaken for any other forms. It is related to a certain extent to the species described before, but it is more extreme in its development in every respect. The ventral valve is still more elevated, and the dorsal median sinus is almost entirely absent. These peculiarities seem to be sufficient to distinguish between the two species; both might, however, be in developmental connection.

Of other forms none needs to be more particularly compared.

II.—Section: PLICATI.

c.—Group of *STREPTORHYNCHUS HALLIANUS*, Derby.

5. Streptorhynchus deltoidens, Waagen, n. sp.

The materials upon which this species is to be founded are rather scanty, only ventral valves in tolerably complete condition being known to me; but the outline of these valves is so peculiar that by them alone most decidedly a separate species is indicated.

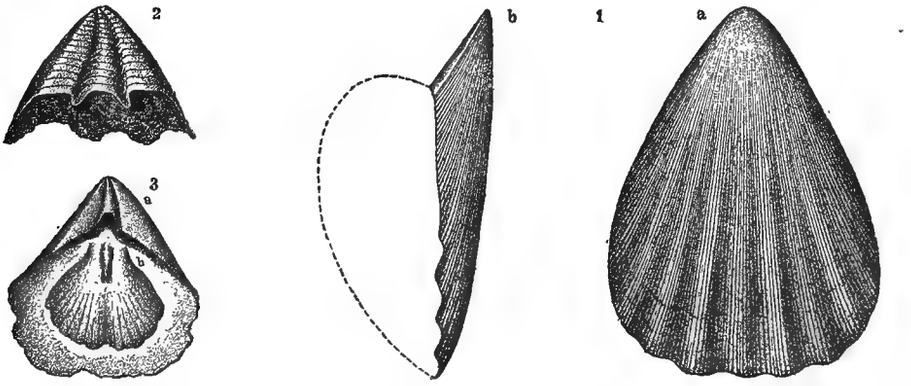


Fig. 15. Streptorhynchus deltoidens, Waagen, n. sp. Fig. 1, ventral valve of a specimen from the middle Productus-limestone of Khura; 1a, ventral view; 1b, lateral view, both natural size. Figure 2, area and dental ridges of a specimen from the middle Productus-limestone of Khuud. Figure 3, ventral view of a partial internal cast from the same bed and locality as the preceding; a, shelly mass filling up the apex of the valve; b, muscular impressions on the cast.

The general outline is elongately triangular, much longer than it is broad, with a nearly quite flat ventral and a strongly inflated dorsal valve. Both valves are plicated, but only near the margins. The species is of a middle size.

The ventral valve is nearly quite flat, and in the longitudinal, as well as in the transverse direction, its bend is very small. In the latter direction, however, it is somewhat more considerable than longitudinally, and the lateral parts especially bend rather abruptly down and even inwards to the hinge-line and the lateral shell-margins. The apex of the valve is very strongly prominent, pointed and not at all bent, quite straight, sometimes slightly twisted to one or the other side. The area is large, very high, but not so very broad, somewhat reclining and interrupted in the middle by a large, vaulted pseudodeltidium. The hinge-line is extremely short. There is no median fold or sinus to be observed in this valve, and the front-line is, excepting the undulations caused by the radial folds, quite straight. The radial folds are very irregular, highest at the margin of the valve, and commencing about half way from the apex. Their number is also very variable.

The interior characters of this valve are well preserved and can be most distinctly made out. They are very similar to those occurring in *Strept. hallianus* as they have been figured by Derby. The short hinge-line is interrupted on both sides of the pseudodeltidium by very strong and prominent hinge-teeth, which are

continued inside the area as prominent ridges up to the apex of the valve. A median septum is altogether absent. The large muscular impressions begin with their upper margins at the same distance from the apex as the termination of the area. The adductor or occlusor impressions are small elongated narrow scars situated in the middle at the upper end of the excavated space. The divaricator impressions, on the contrary, are large and fan-shaped, separated from each other by a slightly raised line and occupying nearly the whole excavated space.

The substance of the shell is for the most part extremely thickened in the apical region in this species, so that often the whole apex down to the hinge-line consists of one compact shelly piece.

The dorsal valve is very imperfectly known to me, as the only specimen in which the dorsal valve is preserved is so firmly impacted in the rock that it is impossible to expose it. Only in making a section through this specimen I learnt that the dorsal valve was strongly inflated and that it possessed a very strong cardinal process.

In one specimen from Khura it is possible to take some of the measurements; they are as follow:—

Entire length of the shell	52 mm.
Length of the dorsal valve, about	43 „
Entire breadth of the shell	39 „
Length of the hinge-line, about	17 „
Entire thickness of the shell	25 „
Apical angle of the ventral valve	72°

The apical angle of other specimens is larger, up to 92°.

Locality and geological position.—There are altogether seven specimens of this species known to me, which are all, however, in rather a fragmentary condition. Six of them were collected by Mr. Wynne at Khund, with silicified shell in a yellowish saccharoid limestone, forming beyond doubt part of the lower region of the middle Productus-limestone. All these specimens are ventral valves only. The seventh specimen I found myself at Khura in a white saccharoid limestone low down in the lower region of the middle Productus-limestone. This specimen is entire, but the dorsal valve is entirely covered by the firmly adhering very hard rock, and could not be cleaned.

Remarks.—The general outline of this species is very peculiar, and thus the species can well be recognised and will not easily be mistaken for any other form. The only species with which it can be more particularly compared is *Streptorhynchus hallianus*, Derby, from the coal-measures of Itaituba in Brazil. Both forms are identical, in the large valve being flat and the small one strongly inflated, in the rudimentary radial plication, and in the arrangement of the muscular impressions in the ventral valve; and thus there can at least be no doubt that they compose one group of very closely related forms. The two species can, however, easily be distinguished by the strangely triangular shape of the Indian shell, which is not to be found in the American species.

Of Indian species only *Strept. pectiniformis*, Dav., which will be described next, can be compared with the shell here under consideration. Davidson's species is, however, distinct, by the much more strongly inflated ventral valve, by the more strongly plicated shell leaving a distinct sinus in the dorsal valve, and by its much thinner shell-substance.

It might be possible that *Strept. deltoidens* is the ancestor of *Strept. pectiniformis*, but I am not sure on the point, and it appears to me that there exists a more close affinity between *Strept. hallianus* and *Strept. deltoidens* than between the latter species and *Strept. pectiniformis*, and according to this opinion I have also grouped the species.

d.—Group of *STREPTORHYNCHUS PECTINIFORMIS*, Dav.

6. Streptorhynchus pectiniformis, Davidson; Pl. LV, figs. 4—11.

1862. *Streptorhynchus pectiniformis*, Davidson: Quart. Jour. Geol. Soc., Lond., Vol. XVIII, p. 30, Pl. I, fig. 17.
1863. *Streptorhynchus pectiniformis* (Dav.), Koninck: Fossiles paléoz. de l'Inde, p. 37, Pl. X, fig. 17.

The species is of a medium size, with inflated valves, a little longer than it is wide, and with many irregular radial folds, which commence only at a certain but very variable distance from the apex. The dorsal valve bears always a more or less strongly excavated median sinus.

The ventral valve is strongly inflated, showing an about equal curving in the longitudinal as in the transverse direction. Of median fold not a trace can be observed. The apex is strongly pointed, but always twisted to one or the other side. It is only slightly bent over. The area is large, always considerably broader than it is high, slightly concave, and interrupted in the middle by a narrow convex pseudodeltidium. The hinge-line is straight and comparatively long, projecting considerably but irregularly on both sides, by which are produced small wings projecting on both extremities of the hinge-line and marked off from the remainder of the shell by a furrow, which extends from the apex down to the end of the hinge-line. The valve is covered with a coarse radial striation only for a length of 15 or 20 millimeters from the apex; coarse plications then begin to appear, which are at first very irregular, and only lower down become more and more regular and equal. The radial striation extends also on these plications, but is very unequal on different specimens. The striation mostly converges irregularly towards the top of the plications, as has been described by Meek in *Meekella striatocostata*, Cox. In other specimens, on the contrary, the striation remains approximately parallel, and only occasionally a convergence at the top of the plications can be observed. The number of plications is very irregular, but in full-grown, well-developed specimens mostly between nine and fifteen folds are present. Young specimens have often much less. The front-line is regularly rounded, slighly depressed in the middle. It presents a zig-zag line from the radial plications.

The dorsal valve is slightly more strongly inflated than the ventral one. Its curve is very regular in both directions, and it is not more strongly inflated in the apical region than elsewhere. A median sinus is always present, but very differently developed in different specimens. It is always very distinctly present in young specimens, beginning very near the apex, but mostly rather narrow. In adult specimens it becomes sometimes deeper and more strongly developed, but sometimes also it becomes less distinct and disappears almost entirely. The consequence is that the front-line in some specimens is strongly depressed in the middle, whilst in others it is nearly straight. The apex of the dorsal valve is pointed but not prominent, lying in one plane with the linear area which extends along the hinge-line. On both sides of the apex distinct wings are developed which give to this valve very strikingly the appearance of a pectenoid shell. The radial striation in this valve is just like that of the other one. On the wings the striation runs parallel to the hinge-line.

Both valves are provided with very strongly imbricating striæ of growth, forming very neat zig-zag lines, and below which the radial striation appears in diverging directions, so as to converge again towards the top of the radial plications. This gives the shell-margin a fringed appearance, as the imbricating striæ of growth are chiefly heaped together near the margin in both valves.

The internal characters of this species could be very accurately ascertained, with the exception of the muscular impressions, which are extremely faint in all the specimens I have for description.

In the ventral valve there are on both sides of the vaulted pseudodeltidium strong, pointed, prominent teeth, which are continued inside the area as prominent, but not very strongly projecting, ridges along the pseudodeltidium up to the apex of the valve. There is not a trace of any septa observable. The muscular impressions, as far as they can be made out, seem to be very similar to those that I have been able to describe in *Strept. deltoidens*, but they are not at all excavated in the present species.

The dorsal valve is provided with a strong cardinal process which projects at about right angles from the plane of the valve. Seen from the dorsal side,—that is, from the outer side of the isolated valve,—this process is slightly bent over the apex of the valve, and bears here in the middle an incision, as if it were pierced by a visceral foramen, which is, however, not the case. From this incision extends a deep groove all along the posterior or dorsal face of the process down to the extremity, which it divides into two by a deep notch. On the sides of the notch two deeply hollowed out elevated ridges extend, so that the extremity of the process is provided with four very acute points, and thus often appears exactly like the extremity of the cardinal process of *Strept. pelargonatus* as figured by Davidson, Pl. II, fig. 39 of the British Permian Brachiopoda.

Laterally there are joined to this median part of the cardinal process two broad wing-shaped shelly plates, which must be considered as continuations of the socket-plates. The dental sockets themselves are small and marked off by a prominent

ridge, which extends from near the apex of the valve to the extremity of the wing-shaped plates. These latter are on their lower side again supported by shelly lamellæ, which extend down to the bottom of the valve and form two short diverging septa. On its lower or ventral side the whole process is entirely smooth.

The muscular impressions in the dorsal valve are also very indistinct. They seem to be large, and separated from each other in the middle by a rather broad smooth space.

The measurements of two specimens, No. I from the Cephalopoda-bed of Jabi, representing the average size of the species, and No. II from the middle Productus-limestone of Swás, a rather small specimen, are as follow :—

	I.	II.
Entire length of the shell	33 mm.	28·5 mm.
Length of the dorsal valve	26 „	19 „
Entire breadth of the shell	32 „	22 „
Length of the hinge-line	19 „	11·5 „
Entire thickness of both valves	21 „	14 „
Apical angle of the ventral valve without the wings	80°	74°
„ „ „ dorsal valve „ „ „	114°	112°

Sometimes, though rarely, the species grows very much larger. The largest specimen known to me I have figured in Pl. LV, fig. 6; it measures 55 mm. in length.

Locality and geological position.—This is a rather common species in the upper division of the Productus-limestone; it is much rarer in the middle division of the same formation. In the lower division it has not yet been detected.

Most common is the species in the Cephalopoda-bed of the upper Productus-limestone. It has been collected in this bed by me at Jabi (15 specimens) and at Chidru (11 specimens). In other beds of the upper division the species has been found at Chidru (8 sp.) by Dr. Oldham and Mr. Wynne, in the mountains east of Katwáhi (2 sp.) by myself, in the section near Khura (2 sp.) also by myself, and at Khund Ghât (3 sp.) by Mr. Wynne.

In the middle division (upper and middle region) of the Productus-limestone the species has been detected at Vurcha (3 sp.) by Mr. Wynne, at Khyrábád (1 sp.) by myself, at Khund (1 sp.) by Mr. Wynne, and at Swás (1 sp.) by Dr. Oldham. Trans-Indus the species has been found in these beds at Káfirkot (2 sp.) by myself, and at Kálabágh (2 sp.) by Mr. Wynne.

Remarks.—From all the species that occur in India this one is easily distinguishable by the strong radial plication it possesses. It is otherwise, however, with respect to *Meekella striatocostata*, Cox, which bears a strong superficial resemblance to the Indian shell. I have remarked already in the description of the genus *Streptorhynchus* that in one specimen of *Meekella striatocostata* I had for comparison I could not detect the dental plates developed in the form of large septa characteristic of genus *Meekella*. Thus it seems probable that also in America species of *Streptorhynchus* occur that are radially plicated and bear in general a very great

resemblance to the Indian *Strept. pectiniformis*, whilst they are at the same time generically distinct from *Meekella striatocostata*. Nevertheless I should not be prepared to admit a specific identity of these American specimens with the Indian shells, on account of the much finer radial striation and the general absence of a sinus in the dorsal valve.

Of other species *Meekella garnieri*, Bayan, from carboniferous beds of China ought to be compared. Of this species, however, it is not known whether it is really a *Meekella* or not, and it appears not improbable that it is a simple *Strept. pectiniformis*. On the whole a certain resemblance to *Strept. pectiniformis* certainly exists, but the only specimen upon which the species has been founded is so badly preserved that it appears impossible to arrive at a positive opinion as to the identity or the difference of the Indian and Chinese forms. If the identity could be proved it would be of interest, as showing with some probability that beds of the age of the Salt-range Productus-limestone exist also in China: *Strept. pectiniformis* being one of the most characteristic species of all the fauna of the Productus-limestone.

In the external form also *Meekella eximia*, Eichw., shows a great resemblance to the Indian *Streptorhynchus pectiniformis*, but not only does Verneuil figure two very strong septa in the ventral valve, but also Trautschold mentions the existence of them, and thus there remains no doubt that the Russian species belongs to the genus *Meekella* and not to *Streptorhynchus*.

7. Streptorhynchus distortus, Waagen, n. sp.; Pl. LV, figs. 12-13.

This is a rather small species, about of the size of *Strept. pelargonatus*, and also otherwise not dissimilar to that shell. Both valves are very much contorted, and thus the general outline is very irregular. Radial plications are present, but they are irregular and not very distinct.

The ventral valve is rather strongly inflated, but of such an irregular curve that it is impossible to give any particulars about it. The apex is pointed, inflated, prominent, and very strongly bent over. The area is very large, concave, and striated, parallel to the hinge-line, as well as vertically. The pseudodeltidium is very narrow, vaulted, and very much shifted to one side, extending from the apex to where the apex of the other valve is situated. The hinge-line is comparatively long, being not much shorter than the greatest breadth of the shell. It terminates on both sides in little wings, very much as occurs in the preceding species. The radial plications begin at a short distance from the apex, are very irregular, and about seven to nine in number. They do not run parallel to the radial striation, but are crossed by it in the most various manner. The front-line forms an irregular zig-zag, and is slightly depressed in the middle.

The dorsal valve is somewhat flatter and less inflated than the ventral one, but its curve is also very irregular. It bears a slight sinus or impression in the middle. The apex is not prominent, not inflated, and often shifted to one side. On

both sides of the apex little wings are developed, from which the valve acquires a more or less pectenoid or aviculoid appearance. The hinge-line is straight; there is no area. The radial plications begin at a short distance from the apex. They are about eight to ten in number, very irregular, and not very prominent. In this valve also they are not parallel to the radial striation.

The radial striation is very fine in this species, much finer than in *Streptorhynchus pectiniformis*.

The internal characters of this species are very insufficiently known to me, only so much is certain that there are no septa in the ventral valve.

The dimensions of a full grown specimen from Virgal are as follow:—

Entire length of the shell	18	mm.
Length of the dorsal valve	13	„
Entire breadth of the shell	15	„
Length of the hinge-line	11	„
Entire thickness of the shell	10	„
Apical angle of the ventral valve without the wings	80°	
„ „ „ dorsal „ „ „ „	115°	

Locality and geological position.—There is only one full-grown specimen of this species preserved in the Salt-range collection. This was found by myself at Virgal in the topmost bed of the upper Productus-limestone. Several specimens which are apparently the young of this species were brought by Mr. Wynne from Bilot, where they occur in a similar geological position as at Virgal.

Remarks.—The present species is in general very similar to *Strept. pectiniformis*, Dav., but can be distinguished from that form by the much finer radial striation, its strongly distorted general shape, large area, and strongly bent-over apex; also the radial plication is less distinct, but is developed at a much earlier period of the shell's growth. It is highly probable that the two species are in a developmental connection.

There is no other species to which *Strept. distortus* could be more particularly compared.

Genus: DERBYIA, Waagen, n. gen.

The existence of this genus was recognised by Prof. Hall so far back as 1874, according to a note contained in Mr. Derby's description of the carboniferous Brachiopoda of Itaituba, but neither Hall nor Derby have given a name to it. Thus nothing remains for me but to give a name to these forms, which I do by calling them *Derbyia* in honour of Mr. Derby, who first drew the attention to the fact that the shells generally considered as *Streptorhynchus* exhibited a widely differing internal structure.

The forms here under consideration can be characterised in the following manner. The general outward appearance is the same as in the shells belonging to the genus *Streptorhynchus*. Internally the dorsal valve bears an extremely large

and massive bifid cardinal process, laterally united to massive shelly plates, which form a kind of diverging septa and partly surround the muscular impressions. These latter are large and deep, but not separated from each other in the middle by a septum.

In the ventral valve a very strong median septum extends from the apex to about half the length of the valve. The hinge-teeth are continued inside the area as prominent ridges up to the apex, and there unite with the median septum. Sometimes, however, this union is not restricted to the apical region alone, where the prominent ridges into which the cardinal teeth are prolonged are changed into a kind of central plates, united to the septum for their whole extent, thus forming a little trigonal chamber under the vaulted pseudodeltidium.

This existence of a very strong median septum in the ventral valve distinguishes the present genus very neatly from *Streptorhynchus ;* whilst this same character as well as the presence of diverging septa in the dorsal valve make it easy to distinguish the genus here under consideration from *Orthothetes*, Fisch., which will be described next.

At the time when Hall drew attention to the peculiarities exhibited by the forms here under consideration, there were only three species known which possessed these peculiarities ; they were *Strept. crassus*, Meek and Heyden, *Strept. robustus*, Hall, and *Strept. senilis*, Phill. To these was added a new species by Derby under the name of *Strept. correanus*, Derb. But these four species already represent two different types, marking two different sections within the genus. One section is typified by *Derb. senilis* and the other old species, which all three have the cardinal teeth free and united to the septum only at the apex ; the other section is typified by *Derb. correana*, in which species the cardinal teeth are supported by short dental plates which are for the whole extent united to the median septum forming a small triangular chamber under the pseudodeltidium.

The latter section I shall call the "*Camerati*," whilst the others I shall call the "*Septati*." The *Camerati* are not represented in the Salt-range, though they are not restricted to the single South-American species *Strept. correanus*, Derb., but have also very interesting representatives in the permian beds of Armenia, the *Derbyia eusarkos*, Abich. (*Strept. crenistria var. eusarkos* and *var. incurvus*, Abich. : Bergkalk v. Djulfa, p. 73), and *Derbyia peregrina*, Abich. Both these species have, for reasons which I cannot quite conceive, been united by Prof. Val. v. Möller to *Strept. pelargonatus*, Schloth., though Mr. Abich in the description very distinctly mentions the ventral septum and the dental plates. These features alone indicate already the great difference that exists between these Armenian forms and *Streptorhynchus pelargonatus*, not to speak of the enormous size and the radial plications of the Armenian species.

The second section, the *Septati*, is largely represented in the Salt-range. The species belonging to this section can be distributed into three groups. The first is the group of *Derbyia senilis*, Phill. That Phillips' *Spirifera senilis* belongs to our genus has been stated already by Mr. Derby, who not only observed the exist-

ence of a large median septum in the ventral valve of European specimens, but also figures a very large cardinal process with shelly supports, forming diverging septa. These observations can also be confirmed by myself, and thus there remains no doubt that Phillips' species forms part of the genus *Derbyia*. It is the prototype of a group of forms for which a more or less inflated apical region of the ventral valve is characteristic. The group is represented in the Salt-range by four species which will bear the respective names of *Derbyia grandis*, W., *Derb. regularis*, W., *Derb. altestriata*, W., and *Derb. plicatella*, W.

The second group is that of *Derbyia crassa*, Meek and Worthen. This group can be recognised by an extremely heavy shell, which chiefly in the ventral valve is enormously thickened. The typical species has been described by the above-named author from the coal-measures of the Upper Missouri, but it seems that species belonging to the same group occur already in somewhat older strata, as in the Mining Journal of St. Petersburg a shell has been figured by Möller from the mountain-limestone of the Ural under the name of *Streptorhynchus crenistria*, which with some probability might belong to the present group. In the Salt-range the group is represented only by a single species, which will receive the name of *Derbyia vercherei*, W.

The third group is typified by *Derbyia robusta* of Hall. The group is easily recognisable by the extremely large, straight and compressed apex of the ventral valve. In India this group is represented also by a single species, which has been identified by Davidson directly with *Orthis robusta*, Hall. To me, however, an absolute identity between the American and the Indian shells seems not to exist, and I should be rather inclined to consider the Indian form as a distinct species, for which I shall introduce the name of *Derbyia hemisphærica*, W.

The grouping of the Indian species can thus be made in the following manner:—

Section: Septati.

a. Group of Derbyia senilis, Phill., sp.
1. *Derbyia grandis*, W.
2. „ *regularis*, W.
3. „ *altestriata*, W.
4. „ *plicatella*, W.

b. Group of Derbyia crassa, Meek & Worthen.
5. *Derbyia vercherei*, W.

c. Group of Derbyia robusta, Hall.
6. *Derbyia hemisphærica*, W.

As regards the geological distribution of this species, the first, *Derbyia grandis*, has been found up to the present in the upper and middle divisions of the Productus-limestone; *Derb. regularis* is restricted to the lower and middle divisions, while *Derb. altestriata* and *Derb. plicatella* occur exclusively in the upper division of the same formation. *Derb. vercherei* is extremely rare and has been found up

to the present only in the middle division and *Derb. hemisphærica* in the upper division of the Productus-limestone.

A fact that has already occurred three times to our observation, and which cannot be passed in silence, is that in several groups of the forms more or less nearly related to *Streptorhynchus* the geologically younger species attain more or less distinctly radially plicated valves. This peculiarity we had occasion to observe in the genus *Streptorhynchus* itself, where the form occurring with or above *Strept. pelargonatus*, *viz.*, *Strept. pectiniformis* and *distortus*, are strongly radially plicated. Quite the same occurs in the genus *Meekella*, the mountain-limestone species, *M. olivieriana*, Vern., being smooth, while the species from the coal-measures and the upper carboniferous-limestone, *M. striatocostata*, Cox, and *M. eximia*, Eichw., have a strong radial plication. Another instance is the section of the "*Camerati*," within the genus *Derbyia*, where the geologically oldest species, *Derb. correna*, Derb., is not plicated; while the permian forms, *Derb. eusarkos*, Abich, and *Derb. peregrina*, Ab., are more or less distinctly radially plicated. Lastly, in the section "*Septati*" of the genus *Derbyia* a similar peculiarity prevails, though in a much less degree. The geologically older species like *Derb. senilis*, Phill., *Derb. grandis*, W., and *Derb. regularis*, W., are smooth, without a trace of a radial plication; *Derb. plicatella*, on the contrary, which occurs in the Cephalopoda-bed of Jabi, has tolerably strong traces of such a plication. It is now in many instances very highly probable that the plicated forms are the descendants of the smooth ones, but if this be the case it is at the same time very improbable that a character which occurs in absolutely the same manner over the whole world should have been caused by external influences as climate, food, &c.; there must have existed within these organisms an innate law, according to which they were forced to assume with the progress of time, sometimes sooner, sometimes later, a radially plicated shape under most widely different external circumstances.

Section: SEPTATI.

a.—Group of *DERBYIA SENILIS*, Phill.

1. Derbyia regularis, Waagen, n. sp.; Pl. LIII, figs. 1, 2, 4.

The general outline of this species is mostly very regularly transversely oval, with a straight hinge-line, which is always shorter than the greatest breadth of the shell, and a not very prominent broad apex to the ventral valve.

The ventral valve is generally slightly vaulted; sometimes, however, it is more or less flat, and rarely even a little concave. In the specimens with a somewhat vaulted ventral valve, which are by far the majority, the curve of this valve is very regular and about equal in both directions. The apex is, however, always more or less flattened and depressed, never pointed and prominent. The area is largely triangular, flat, and crossed by numerous imbricating striæ of growth disposed

parallel to the hinge-line. In the middle there is a rather large vaulted pseudodeltidium, which bears a distinct longitudinal furrow. This furrow is of great importance, as it indicates the existence of a median septum inside the valve. A trace of this furrow seems visible in Davidson's drawing, Pl. XXVII, fig. 2*b*, of his Carboniferous Monograph, representing the area of the original specimen of *Derb. senilis*, Phill. The surface of the valve is ornamented with some rounded concentric waves and numerous little, far separated imbricating striæ of growth. The margins of the valve are everywhere rounded, and even the corners in which the hinge-line terminates do not much project. The frontal line is nearly quite staight, only very little depressed in the middle.

The dorsal valve is much more strongly vaulted than the ventral one, and its curve is very regular and equal in both directions. The hinge-line is comparatively long and straight, and the valve is somewhat flattened towards both ends of this line, whereby a kind of flattened wing is formed on each side. There is an area developed in this valve, but it is very narrow, nearly linear. The apex is well bent over and not prominent. There is never a median sinus in this valve, though the front-line is slightly depressed in the middle. This valve also is ornamented with small numerous far distant imbricating striæ of growth; they are, however, entirely absent from a large space round the apex which is a very striking character of this species. Concentric wrinkles or waves as in the other valve are only rarely developed in this one, and if they are present, they are very indistinct.

The radial striation is very fine in this species, 7 to 8 striæ within the space of 5 millimeters. It is very regular and not interrupted by striæ of growth for a space of about 30 mm. from the apex of each valve, and augments as the shell increases in size by intercalation of new ribs.

The internal characters of this species are not quite perfectly known to me. In the ventral valve the median septum seems not to be very strongly developed, and apparently reaches on the anterior (dorsal) side only to half the length of the pseudodeltidium. On the other side it reaches down much lower and occupies about a third of the entire length of the valve.

In the dorsal valve the cardinal process is almost completely known to me. I have worked it out in a specimen from Swás, and only the termination of the process has been broken in thus preparing it. The process proceeds straight up from the hinge-line, it being situated in the plane of the valve, an arrangement which is necessitated by the little inflation of the apex of the ventral valve. Considered from the dorsal side (Pl. LIII, fig. 4*a*) the process consists of two parts, which are separated from each other by a deep and narrow furrow hemmed in on both sides by prominent ridges having a furrow at top. The process projects far above the hinge-line, is rather massive, and terminates in two short rounded branches. On the ventral face (Pl. LIII, fig. 4*b*) a strong median septum rises up, where on the other side the median furrow commences. It bifurcates where the process divides, and each branch is ornamented with a branch of the septum up to the top. On both sides of the process the dental grooves are situated (Pl. LIII,

fig. 4*c*). The shelly plates forming these grooves are continued into diverging septa, which descend a good distance into the interior of the valve. Above the dental groove the septum is drawn out into a shelly lobe which recalls somewhat the crura of the *Rhynchonellidæ* and might perhaps be the morphological representative of those organs.

I was not able to make out the muscular impressions of any of the valves.

The measurements of a large specimen from Vurcha are as follow :—

Entire length of the shell	73 mm.
Length of the dorsal valve	64 „
Entire breadth of the shell	88 „
Length of the hinge-line	66 „
Entire thickness of the shell	36 „
Apical angle of the larger valve	155°

The species seems not to become larger than the specimen of which the measurements are here given.

Locality and geological position.—This species commences in the lower division of the Productus-limestone and extends up into the middle division of the same formation, where it also terminates. In the upper division it is replaced by a smaller form which will be described next.

In the lower division the species has been collected by myself at Amb in the coaly sandstones forming there the lowest fossiliferous beds above the lavender-clays (4 sp.).

In the middle division the greatest number were found by Mr. Wynne, at Vurcha, in a shaly bed between the limestones (11 sp.). Another specimen was collected also by Mr. Wynne at Chidru.

Remarks.—This species is very nearly related to *Derbyia senilis*, Phill., as well as to *Derbyia robusta*, Hall, and seems to keep about the middle between the two forms. From the first species the present one seems to differ by the smaller area and the less strongly inflated ventral valve, as well as by a considerably finer and more regular radial striation. The slightly raised vertically striated median part of the area which appears very distinctly in some specimens of *Derb. regularis* seems to be absent in *Derb. senilis*. These differences may be sufficient to distinguish the two forms. On the whole it is, however, extremely difficult to distinguish the several species within the genus *Derbyia*, as the forms are very variable, and seem to be linked together by more or less numerous transitional shapes. Nevertheless I think the distinction of species should not be given up altogether, for this reason, that the typical shapes are always prevalent and often by their occurrence in certain distinct beds are of great geological importance. As in several of the genera of the *Terebratulidæ* so in this genus the production of hybrids seems to have occurred very frequently.

The distinction from *Derbyia robusta*, Hall, is not difficult if we compare typical specimens, as in these the ventral valve is more strongly vaulted, and the whole shell more lenticular in the Indian form. In other specimens, however, the ventral

valve becomes more flattened, and then the Indian shell may become very similar to *Derbyia robusta*, but also in those specimens a decidedly distinguishing character consists in the constantly shorter hinge-line of *Derbyia regularis*. While in *Derbyia robusta* the hinge-line is very nearly as long as the greatest breadth of the shell, it is always very considerably shorter in *Derbyia regularis*, and thus again the Indian species seems distinguishable from the American form.

1*a*. Derbyia regularis, W., var. minor.

There occurs in the upper division of the Productus-limestone a species of *Derbyia* which is in all respects very similar to *Derbyia regularis*, except that it never attains nearly the size of the typical form and exhibits always a concave ventral valve. I should have distinguished this form as a proper species, but that also among the typical *Derbyia regularis* specimens occur having a concave ventral valve. It is true that this form, which constantly remains smaller and bears a concave ventral valve, is entirely restricted to the upper Productus-limestone, and also on geological grounds the form might well bear a proper designation, but considering the general extreme variability of the shells belonging to this genus, it would not seem quite prudent to create, on the evidence before me, a quite distinct species of these smaller specimens.

The measurements of two specimens, No. I from Kufri and No. II from Katwáhi, are as follow :—

	I.	II.
Entire length of the shell	57 mm.	50 mm.
Height of the area in the ventral valve	11 „	11 „
Length of the dorsal valve	49 „	48 „
Entire breadth of the shell	68 „	63 „
Length of the hinge-line	64 „	45 „
Entire thickness of both valves	23 „	26 „
Apical angle of the ventral valve	133°	141°

Locality and geological position.—The variety is not very rare at certain places in the upper division of the Productus-limestone. It has been collected by myself at Kufri (6 sp.) and by Mr. Wynne west of Katwáhi (1 sp.) and at Chidru (1 sp.).

2. Derbyia grandis, Waagen, n. sp.; Pl. LI, LII, figs. 1 & 3; LIII, figs. 3 & 5.

1862. *Streptorhynchus crenistria* (Phill.), Davidson: Quart. Journ. Geol. Soc. Lond., Vol. XVIII, p. 30.

The general outline of this species is very irregular, more or less semi-circular, the hinge-line being about as long as the greatest breadth of the shell; the valves are not very strongly inflated, and the apex and area tolerably large and prominent. Both valves are covered by very irregular more or less concentric wrinkles.

The ventral valve is not much vaulted, though it is rather thick and inflated. In the longitudinal direction it is barely arched at all, while transversely it is rather strongly curved chiefly towards the lateral margins, and in the middle it appears often more or less flattened. The apex is promiment but not pointed, sometimes

slightly bent over, sometimes not at all, always more or less twisted to one or the other side. The area is large, triangular, but forming a very irregular triangle, in which only the hinge-margin forms a straight line. The area is sometimes slightly concave, sometimes not, and mostly rather strongly reclining. In the middle it is interrupted by a comparatively very narrow pseudodeltidium, which is slightly vaulted and bears in the middle a very distinct longitudinal furrow. On both sides of the pseudodeltidium a slightly raised triangular platform is marked off, which sometimes bears a distinct vertical striation, while on the remainder of the area only parallel slightly imbricating striæ of growth can be observed. The hinge-line is nearly as long as the greatest breadth of the shell, but does not cause the formation of distinct wings. The surface of the valve is covered with very irregular concentric wrinkles or waves, which mostly coincide with rather strongly imbricating striæ of growth. The apex of this valve is often so much deformed that it appears as if the shell had been fixed to some foreign body during youth. As the apex is more deformed, so also is the remainder of the valve crumpled in all possible directions.

The dorsal valve is less strongly inflated than the ventral one, yet it is much more strongly curved in every direction. The apex is slightly prominent, sometimes much vaulted, and sometimes rather flattened, but from the apex down to the front-line the valve extends always in a rather bold curve. In the transverse direction the curve is somewhat less considerable, chiefly towards both ends of the hinge-line the valve appears considerably flattened and thus indistinct wings are formed, by which this valve is well characterised. All along the hinge-line a very sharply defined but very narrow area extends. Though a distinct median sinus from the apex down to the front cannot be observed, yet there exists a kind of a median depression, which is sometimes more, sometimes less developed, and though often interrupted by the concentric wrinkles, it always produces a more or less strong median depression of the front-line. The concentric wrinkles are as numerous but less strongly prominent than in the ventral valve.

The radial striation is tolerably fine, sharp, but not prominent. In all specimens it is locally very irregular, the separate striæ running into one another, &c. This is caused by frequent injuries received during lifetime when the animal mended its shell as best it could. How serious such injuries must have been is shown in the specimen figured in Pl. LII, fig. 1*a*; on the left of the specimen is a large space where the shell had been broken and is now in the first stage of repair. It is remarkable that the specimens belonging to this particular species are subject to such frequent injuries; it must have been a favourite food of some large fish.

The internal characters of this species are not entirely known to me, as the muscular impressions of the dorsal valve could not be made out.

The internal characters of the ventral valve can be seen as well on the partial cast figured, Pl. LI, as on the internal cast of a small specimen that is represented in Pl. LIII, fig. 3. The hinge-teeth are situated on both sides of the pseudodeltidium, and are continued inside the area as prominent ridges up to the apex of the valve. Between these ridges a thin median septum extends, which is, however, not

sufficiently high to reach the lower margin of the pseudodeltidium and thus to fill the whole cavity of the beak. On the bottom of the valve this median septum reaches down for about one-third or somewhat more of the entire length of the valve. It then divides in two branches, which encircle the muscular impressions and terminate before they reach the apex of the valve. The muscular impressions themselves are large and multilobed. These large scars are evidently the impressions of the divaricators, whilst the adductors apparently have left long narrow impressions on both sides at the base of the septum.

In the dorsal valve the most conspicuous feature is the enormous cardinal process, which I had occasion to observe in several specimens. I have figured a tolerably complete specimen, Pl. LIII, fig. 5, from which it appears at a glance that this process is much more massive in the present species than in the preceding one. It does not rise straight up from the apex of the valve, but projects under a more or less obtuse angle from it, and is at the same time considerably curved, the convex side of the curve being on the ventral, the concave on the dorsal side of the process. The ventral side of the process is entirely smooth, and does not bear a prominent septum-like ridge as in the preceding species. On the dorsal side the process bears in the middle a very deep and rather broad furrow, which towards the end of the process divides it into two thick short prongs. On both sides of this median furrow ridges extend up to the end of the prongs, which are broadly furrowed on the top. Laterally the cardinal process is united to the socket-plates. The dental sockets are large and roundish, marked off by a spur which projects from the hinge-line. The socket plates are continued towards the interior of the shell as thick diverging septa. At the place where the socket-plates unite with the cardinal process a broad wing-shaped shelly projection is formed which is probably the morphological representative of the crura of *Rhynchonellidæ*. The similarity is augmented by a prominent ridge, which originates not far from the apex, runs along above the dental sockets, and terminates with a gentle inward curve at the extremity of the shelly projections just described—a position which exactly corresponds to the position of the crura of a *Rhynchonella*. The exact form of the muscular impressions of this valve is not known to me.

The measurements of two specimens, No. I from Káfirkot, and No. II from Musakheyl, are as follow:—

	I.	II.
Entire length of the shell	116 mm.	86 mm.
Length of the dorsal valve	96 „	72 „
Entire breadth of the shell	119 „	96 „
Length of the hinge-line	102 „	86 „
Thickness of both valves	49 „	39 „
Apical angle of the larger valve	143°	? 136°

The specimen No. I is the largest that has been observed by me.

Locality and geological position.—This species occurs throughout the middle and upper divisions of the Productus-limestone, but in the upper division it becomes generally not quite so large as in the middle one.

In the middle Productus-limestone the species has been found by myself at Chidru (2 sp.), in the mountains east of Katwáhi (1 sp.), and at Káfirkot (1 sp.). Mr. Wynne brought the species from the Bazárwán (1 sp.), from north of Katwáhi (1 sp.), from Morah (1 sp.), from the Chittawán (1 sp.), from Khyrábád (1 sp.), and from north of Káfirkot. An excellent specimen has been contributed by Dr. Warth from Musakheyl.

In the upper Productus-limestone the species has been obtained by Mr. Wynne at Khund Ghát (8 sp.), and by myself in the section at Kufri (2 sp.), and in the Cephalopoda-bed at Chidru (1 sp.).

Remarks.—This species is very nearly related to *Derbyia senilis*, Phill., with which in fact it has been identified by Mr. Davidson. The distinctive characters which are sufficient, according to my view, to distinguish the Indian form as a proper species, consist in a yet greater irregularity of growth, in a less prominent apex, a by far smaller area and longer hinge-line, and in a very considerably narrower pseudodeltidium in the Indian shells. Also the size is not nearly reached by European specimens. These characters might be sufficient for the distinction of the species, though by some people they may not be thought so; it cannot, however, be denied that the Indian shell does not exhibit the typical shape of the specimens of *Derb. senilis* occurring in the European mountain-limestone. Thus I think it is more prudent to give a new name to the Indian form than to quote it under the name of a species with which it does not entirely agree.

Also *Derb. regularis* is similar to a certain extent to the present species, but it can be much more easily distinguished by the more regular shape, the sporadic occurrence of a concave ventral valve, which never has been observed in *Derb. grandis*, and by its finer radial striation.

3. Derbyia altestriata, Waagen, n. gen. et sp.; Pl. LII, fig. 2.

This species is of a middle size, with a more or less semi-circular outline and approximately lenticular shape. The most striking character, however, consists in the extremely coarse and raised radial striation.

The ventral valve is rather flattened and but very little vaulted in both directions. The apex is pointed, but very little prominent. The area not very large and strongly reclining; it forms a tolerably regular, flat, horizontally striated triangle, in the middle of which a narrow vaulted pseudodeltidium is situated, which latter bears on the top an excavated line extending nearly down to the hinge-margin. The surface of the valve is covered with distant, very prominent concentric wrinkles which are tolerably regular, and give to this valve a characteristic appearance. The frontal margin is slightly cut out in the middle.

The dorsal valve is much more strongly inflated and vaulted than the ventral one; its curve is, however, about equal in the longitudinal direction as well as in the transverse one. The apex is slightly prominent, pointed, and strongly bent over. The area of this valve is narrow but very distinct. On both sides of the

apex, along the hinge-line, the valve is considerably flattened and spread out, forming indistinct wings. From the apex down to the front a shallow and not very broad but yet quite distinct sinus extends. This valve also bears a concentric sculpture, but in the opposite sense of that of the other valve—that is to say, there is a depression or furrow in this valve, where there is an elevated wrinkle or wave on the other one. The concentric imbricating striæ of growth are much less conspicuous in this than in other species of *Derbyia*.

The most characteristic feature is the radial striation. It is coarser and the single ribs are more highly elevated than in any other species of *Derbyia*. I have seen up to the present their height reaching nearly one millimeter. At the same time the fine scaly concentric striation, which occurs in nearly all the *Orthothetinæ* is very distinct and coarse in this species. The radial striæ augment but rarely by intercalation.

Of the internal structure of this species but very little is known to me, only the strong median septum of the ventral valve being visible in one of the specimens.

The measurements of the larger of the two existing specimens are as follow :—

Entire length of the shell	38 mm.
Length of the dorsal valve	36 „
Entire breadth of the shell	46 „
Length of the hinge-line	37 „
Entire thickness of both valves	20 „
Apical angle of the ventral valve	140°
„ „ „ dorsal „	100°

Locality and geological position.—There are altogether only two specimens of this species preserved in the Salt-range collection. Both were found by myself at Jabi in the Cephalopoda-bed of the upper division of the Productus-limestone.

Remarks.—This species is more or less nearly related to all the species previously described. It can, however, be distinguished from all of them by the regular shape, the strong concentric wrinkles, which are prominent folds on the ventral and depressions on the dorsal valve, and by the much stronger and higher radial striation. These same characters are also sufficient to distinguish the present form from other species which have not been described in this work. Thus it can well be distinguished from *Derb. senilis*, Phill., and others, and so it forms, I consider, a sufficiently distinct and well-distinguishable species.

4. Derbyia plicatella, Waagen, n. gen. et sp.; Pl. LV, fig. 3.

This is a very rare middle-sized species, of an about lenticular shape, with not very inflated valves, and not very strongly developed radial plication.

The ventral valve is tolerably strongly vaulted, with an about equal curve in both directions. The apex is rather much inflated, pointed, and strongly bent over. The area is broad, high and strongly concave, provided with many imbricating striæ of growth parallel to the hinge-line. The pseudodeltidium is large and not quite distinctly defined. The sculpture of this valve besides the radial striation consists for the greater part of irregular concentric wrinkles, which often appear as high concentric folds and are more or less in connection with strong imbricating striæ of

growth. A short distance from the margins of the valve the concentric sculpture disappears more or less, and gives way to a radial one, which consists of very irregular not very high radial plications, giving to the margin of the valve more or less the form of a zig-zag line. The lateral parts of the shell margin are slightly depressed, while the median or frontal part is somewhat bent up, without, however, a distinct median fold being formed on this valve.

The dorsal valve is perhaps a little more strongly vaulted than the ventral one, and its curve is very regular in both directions. The apex is barely prominent, pointed, but not at all inflated, rather flattened. It is not bent over. The area is narrow but very distinct. Towards both ends of the hinge-line the valve is somewhat flattened and spread out, forming a kind of wings. The valve shows a concentric sculpturing, consisting of folds and depressions, but it is much less strongly developed in this than in the other valve. Not far from the margin also in this valve this sculpturing disappears to be replaced by a radial one. This latter consists of very irregular coarse radial folds, some of which begin earlier, some later, but which are all most strongly developed at the shell-margin itself. Also their lateral distance from each other is very irregular. The front-line is depressed, but without the formation of a distinct median sinus.

The radial striation of both valves is rather fine, and the single striæ are also rather low, just the contrary of what is the case in the preceding species.

Of the internal characters of this species only the very strong median septum in the ventral valve can be observed. The substance of the shell is very thin.

The measurements of the only existing specimen are as follow :—

Entire length of the shell	47 mm.
Length of the dorsal valve	40 „
Entire breadth of the shell	52 „
Length of the hinge-line	38 „
Entire thickness of both valves	27 „
Apical angle of the ventral valve	131°

Locality and geological position.—This is a very rare species, and up to the present only a single specimen of it has been detected. This was found by myself at Jabi, in the Cephalopoda-bed of the upper Productus-limestone.

Remarks.—It is not difficult to distinguish this species from others of the same genus. The strongly concave area, the fine radial striation, and the radial folds by which its margin is ornamented, are characters which in the same combination are not to be found in any other species.

Of not Indian species none can be more particularly compared to the present one.

b.—Group of *DERBYIA CRASSA*, Meek and Hayden.

5. Derbyia vercherei, Waagen, n. gen. et sp.; Pl. LIV, fig. 4.

As all the species of this group so also the present one is characterised by an extremely heavy and ponderous shell, of an about trapezoidal outline.

The ventral valve, the only one known to me, is nearly quite flat, partly even slightly impressed, and only the extremely thickened shell-margin is again strongly bent up. The apex is but little prominent and not pointed, the area small, but very little reclining. It is quite flat, not in the slightest degree concave or vaulted. In the middle it is interrupted by a broad but short pseudodeltidium, which does not entirely fill up the deltidial fissure, but is largely cut out at its lower extremity, apparently to allow of the passage of a rather large pedicle. The pseudodeltidium is but very little vaulted, and bears in the middle a longitudinal impression, by which circumstance the presence of a median septum inside the valve is marked. On both sides of the pseudodeltidium a rather large slightly raised triangular platform is marked off, which bears a very distinct vertical striation. Otherwise the area is only sculptured by distant very strong imbricating striæ of growth, which extend parallel to the hinge-line. Along the hinge-line the enormously thickened shell-substance forms a flattened space, which apparently has been covered up by an equally thickened hinge-region of the dorsal valve. Near the hinge-teeth and outside of them, this flattened space bears narrow elongated grooves, which apparently served for the reception of a kind of hinge-teeth of the dorsal valve, with which apparently the present species has been provided. The external surface of the ventral valve is in its sculpture very much like that of other species of the same genus. It is provided with extremely strongly imbricating striæ of growth, which are nearly absent up to a distance of 35 mm. from the apex, after which up to 60 mm. some strong ones occur, when the shell-margin suddenly bends up, and countless scaly striæ of growth are heaped together. The front-line is straight, the hinge-line is much shorter than the greatest breadth of the shell, and this latter is situated nearer to the front than to the hinge-line.

The radial striation is not very fine nor sharp. It is crossed as in other species by neat concentric striæ, which give a somewhat scaly appearance to the radial striæ.

The internal characters are excellently visible on the specimen at my disposal. The hinge-teeth are continued inside the area as prominent ridges extending on both sides along the pseudodeltidium; but they are not so strongly developed as to form distinct septa which would extend down to the bottom of the valve and divide the interior of the beak longitudinally into different parts. The muscular impressions are very deep and very large, occupying half of the entire length of the valve. They are surrounded by a high undulating shelly crest, which flattens where it approaches the cardinal region, thus not uniting to the dental ridges. The whole space of these muscular impressions is divided longitudinally by a very high and sharp median septum, which commences at the apex and extends down to the end of the muscular impression. Towards the extremity of the beak, this septum reaches up from the bottom of the valve to the pseudodeltidium, and is grown together for a certain extent with it, but lower down the pseudodeltidium becomes again free. On both sides of this septum one should expect to find the impressions of the adductors, while the larger part of the whole impression would be due to

the divaricators. I am, however, quite unable to distinguish the adductor impressions, and I cannot say how the adductors may have been fixed.

The measurements of the only existing specimen are as follow: —

Entire length of the shell	68 mm.
Height of the area	11 „
Length of the median septum	33 „
Entire breadth of the shell	72 „
Length of the hinge-line	52 „
Thickness of the valve at lower margin of area	10 „
„ „ „ at the frontal margin	16 „
Apical angle	140°

Locality and geological position.—The only specimen of this species that is known to me consists in a quite free ventral valve of enormous thickness which was found by Dr. Verchere at Bilot (trans-Indus). The bed from which the specimen came is not exactly known, but from its mode of preservation it appears very probable that it came from the middle division of the Productus-limestone.

Remarks.—It cannot be denied that the materials upon which this species is founded are barely sufficient for the purpose, but on the other hand the form can be so well and easily distinguished from all the other species of the genus occurring in the Salt-range, that on this ground alone it may be useful to distinguish it. At the same time it is of much interest that the Indian shell is so very nearly related to *Derbyia crassa*, Meek. and Hayden, of the American coal-measures.

From all the Indian species *Derbyia vercherei* can be distinguished by its regular outline, flat ventral valve, little prominent beak, and the enormously thickened shell-substance. By this latter character as well as by the largeness of the muscular impressions in the ventral valve, the species here under consideration approaches very closely the *Derbyia crassa*, from which it can be distinguished by its much larger size and the much more strongly developed median ventral septum.

Also in Europe very nearly related forms seem to occur; at least there has been figured by Möller a ventral valve from the upper carboniferous-limestone of the Ural, under the name of *Strophomena crenistria*, Phill., which is apparently very like the species I have here described under the name of *Derbyia vercherei*.

All these seem to constitute one group of forms which is easily distinguishable and well characterised by the extreme heaviness and solidity of the shell.

c.—Group of *DERBYIA ROBUSTA*, Hall, sp.

6. Derbyia hemisphærica, Waagen, n. gen. et sp.; Pl. LIV, figs. 1—3.

1862. *Streptorhynchus crenistria* (Phill.), var. *robusta* (Hall), Davidson: Quart. Journ. Geol. Soc., Lond., Vol. XVIII.

1863. *Streptorhynchus crenistria*, Phill., var. *robusta* (Hall—Davids.), Koninck: Fossiles de l'Inde, pag. 36, Pl. X, fig. 16.

This species is always of a middle size, and never becomes so large as the preceding one. One valve is quite flat, the other very strongly inflated, and the

beak is very strongly prominent and compressed. The whole shape of the shell is mostly quite regular.

The ventral valve is quite flat, very rarely slightly concave. Only towards both ends of the hinge-line the margins of the valve are slightly bent up. The hinge-line is always a good deal shorter than the greatest breadth of the shell. The area is extremely large, triangular, and more or less reclining. It is quite flat, and ornamented only by usually not well-marked imbricating striæ of growth which extend parallel to the hinge-line. In the middle, on both sides of the pseudodeltidium, there is again a slightly raised space which mostly bears a faint vertical striation. The pseudodeltidium itself is narrow, very little vaulted, and bears a slight longitudinal impression in the middle. The surface of the valve is ornamented by distant, sometimes imbricating striæ of growth. The margins are either all in one plane or the frontal margin appears slightly depressed.

The dorsal valve is very strongly inflated, more or less hemispherical. Its curvature is equal in both directions, and only towards both ends of the hinge-line it is slightly flattened, so that a kind of small wings is formed. These are sometimes less strongly developed, but never stronger than in the specimen figured by Davidson in the Quarterly Journal. The apex of this valve is not at all prominent and very strongly incurved. The area is distinctly developed, though very narrow. The surface of the valve is covered by distant, sometimes imbricating striæ of growth.

The surface sculpturing consists in both valves of a fine radial striation, which is crossed by very fine, concentric, somewhat scaly striæ of growth. There exists, however, at the same time in this species a great propensity to form a radial plication, but which never becomes very distinct. Traces of such a plication are visible on the specimen figured by me, Pl. LIV, fig. 2*b*. In other specimens this plication becomes yet stronger, and chiefly on the dorsal valve it can then be distinctly seen. The majority of specimens remain, however, smooth.

The internal characters are only very imperfectly known to me. The median septum in the ventral valve is very strongly developed, and divides the interior of the beak in two halves nearly down to the hinge-line. The hinge-teeth are strong and continued inside the area as prominent ridges up to the apex. The muscular impressions are large and deep. In the dorsal valve the cardinal process seems to be not very large. The dental sockets, however, are supported by shelly plates, which extend far inside the valve as prominent diverging septa. The muscular impressions of the dorsal valve are not known to me.

The measurements of two specimens from Khura are as follow:—

	I.	II.
Entire length of the shell	50 mm.	54 mm.
Length of the dorsal valve	40 „	43 „
Entire breadth of the shell	51 „	54·5 „
Length of the hinge-line	45 „	48 „
Entire thickness of the shell	30 „	30 „
Apical angle of the ventral valve	130°	130°

The species never becomes larger than the specimens of which the measurements are here given.

Locality and geological position.—The species is almost entirely restricted to the upper division of the Productus-limestone and has been found up to the present only in very sporadic specimens in the uppermost beds of the middle division.

In the Salt-range collections there is a single specimen from the limit between the upper and middle divisions of the Productus-limestone. This specimen was collected by Mr. Wynne, trans-Indus at Kálabágh.

All the other specimens are from the upper division. The species has been found in these beds at the following localities: At Khund Ghat (21 sp.) and at Nurpur (1 sp.) by Mr. Wynne; at the section near Khura (5 sp.) and west of the same village (3 sp.) as well as at Chidru (1 sp.) by myself. Dr. Warth brought the species from Musakheyl (1 sp.), not from the bed with silicified fossils, but from a bed of sandstone in which the fossils are contained in a calcareous condition. There is but little doubt that this sandstone forms part of the upper division of the Productus-limestone.

Remarks.—This species has been identified by Mr. Davidson with *Orthis robusta* of Hall, and it cannot be denied that the similarity between the Indian and the American shells is very great. Nevertheless I should not be quite inclined to adopt Davidson's opinion. If within that group of forms which has up to the present generally been united under the name of *Streptorhynchus crenistria*, Phill., we once come to distinguish several different genera, according to the different internal structure that occurs in these shells, we are then also obliged to draw the limits of the different species somewhat more closely, and to consider forms as specifically different, which formerly would not have been so distinguished. In such a position are we also in this case; and though I believe that *Derb. robusta*, Hall, and *Derb. hemisphærica*, W., belong to one and the same group of forms, yet I think that the two shells must be considered as specifically different. The Indian shell can easily be distinguished from the American one by the always less considerable size, an outline in which length and breadth are nearly equal, and the by far more strongly developed beak.

But in Europe as well as in America there occur forms which are very similar to the present species. Among these chiefly *Streptoryhnchus crenistria*, Phill., var. *cylindrica*, M'Coy, must be mentioned. Of this form excellent figures have been given again by Mr. Davidson in his Supplement to the British Carboniferous Brachiopoda. From these figures it appears that the European form differs from the Indian one chiefly by the concave ventral valve. In the cast represented in fig. 7 by Davidson this concavity seems to be less developed, but this cast is otherwise very different and must be put into the genus *Meekella*. It could perhaps be compared to *Meekella olivieriana*, Vern.

Of other Indian species several must be compared. There is before all *Derbyia regularis*, var. *minor*, W., which in general appearance is rather similar to the

present species. It can be distinguished by its much smaller and less prominent beak and the flatter dorsal valve; also in its general outline it is often much less regular than *Derb. hemisphærica*.

Derbyia vercherei, W., which is also similar, can be well distinguished by its larger size, smaller beak, and the extreme thickness of its shell-substance.

Genus: ORTHOTHETES, Fischer v. Waldheim.

Though this name has been quoted as applied by Evans to certain forms already in the year 1829, yet the genus cannot be considered as fairly established before the year 1830, when in the first edition of the "Oryctographie" the interior of a dorsal valve was distinctly figured and the genus definitively transferred to the Brachiopoda by Fischer v. Waldheim. In the edition of 1830 only the interior of the dorsal valve was figured, whilst in the edition of 1837 an external view of a ventral valve is added.

In both cases there cannot remain the slightest doubt that the name was applied to a shell very nearly related to *Streptorhynchus crenistria*, Phill., and which chiefly in the internal characters of the dorsal valve is generically identical with Phillips' species. The name must thus be restricted to those forms and the genus may be characterised in the following manner:—

The external shape of the shells belonging to this genus is in no way characteristic, and it is only by the internal characters that the genus can be recognised.

In the dorsal valve a cardinal process of moderate dimensions exists, which is generally bifid and comparatively broad. Laterally it is joined to the walls of the dental sockets. These latter are not very large and not supported by shelly lamellæ, so that the diverging septa, which are characteristic of the preceding genera, are absent in the present one. Instead of these, however, there seems to be not rarely a median dorsal septum developed, which is immediately joined to and takes its origin at the cardinal process. This median dorsal septum appears on Fischer v. Waldheim's original figure as well as on Pl. XXVII, fig. 6, of Davidson's Carboniferous Monograph.

In the ventral valve, as far as my experience goes, every kind of septum is absent.

The muscular impressions of both valves have been excellently described by Mr. Davidson, but they are in their general arrangement very similar to the muscular impressions of other genera.

There can be no doubt that *Strept. crenistria*, Phill., belongs to this genus, even if it should be proved that Fischer v. Waldheim's original specimen did not belong to the same species. Also the species or varieties *St. radialis*, Phill., and *St. arachnoidea*, Phill., perhaps too the typical *St. cylindrica*, M'Coy, will have to be connected to it. Otherwise not much is known of species of the genus. There has been described a species belonging to this genus by Derby under the name of *Strept. tapajotensis*, from the coal-measures of Brazil, and of devonian species are quoted also by Derby, *Strept. arctostriata*, Hall, *St. pandora*, Hall, and *St. agassizi*, Hartt.

Also *Strept. devonicus*, Orb., which has been placed by Derby in another group of forms, belongs, in my opinion, to this genus, as the diverging septa of the dorsal valve, characteristic of the preceding genera, are absent in it.

In the Salt-range the genus is represented by a single species, which will bear the name of *Orthothetes semiplanus*, W.; it occurs in the Cephalopoda-bed of the upper Productus-limestone.

It is impossible to tell whether this species is in a more or less close relation to the *Orthothetes crenistrata*, *Orthoth. radialis*, or any of the other species. As yet too little is known of these to attempt a definite grouping of the species.

1. Orthothetes semiplanus, Waagen, n. sp.; Pl. LV, figs. 1, 2.

This species is of rather small size, and of a characteristic transversely oval outline. Of the two valves, the larger one is depressed conical, the smaller quite flat. The hinge-line is slightly shorter than the greatest breadth of the shell.

The ventral valve is of a flatly conical shape, rather strongly vaulted in the transverse, and but little arched in the longitudinal direction. The area is very large, flat, triangular and strongly reclining. It is interrupted in the middle by a very large strongly vaulted pseudodeltidium. The apex is prominent, pointed, and bent over just at its extremity. The surface of the valve is smooth without a median fold or sinus. Besides the radial striation, which is very unequal in strength and resembles in this respect somewhat that of *Orthothetes radialis*, Phill., there are only some strong imbricating striæ of growth at very irregular distances. The margins are all in one plane and the frontal one is not at all or only very slightly indented. The dorsal valve is quite flat and not vaulted in any direction. Only in the middle it is slightly depressed, so that a kind of very flat and broad median sinus is formed. The apex is entirely flattened, neither prominent nor pointed. The hinge-line is straight, provided with a narrow but very distinct area. In the middle it is somewhat swollen where the cardinal process is fixed to it. The radial striation is less unequal in strength in this valve than in the other one. The concentric imbricating striæ of growth are also less strongly developed. The frontal margin is mostly slightly depressed.

Of the internal characters of this species but little is known to me, as the specimens were too few to allow of investigations in this direction. From an isolated dorsal valve from Chidru it is, however, possible to state that the cardinal process is short, bifid and rather broad, in shape very similar to that of *Orthothetes tapajotensis* as figured by Mr. Derby. Diverging septa are absent. The interior of the ventral valve is entirely unknown to me.

The measurements of a rather small specimen from Jabi are as follow:—

Entire length of the shell	21 mm.
Length of the dorsal valve	17 „
Entire breadth of the shell	25 „
Length of the hinge-line	22 „
Entire thickness of the shell	10 „
Apical angle of the ventral valve	113°

Locality and geological position.—There are altogether only two specimens of this species known to me, both from the Cephalopoda-bed of the upper Productus-limestone. They were collected by myself, a bi-valved one at Jabi, and the other, a dorsal valve only, at Chidru.

Remarks.—There can be, I think, but little doubt that the present species belongs to the genus *Orthothetes*, though the internal characters could not be entirely made out; but it is very difficult to ascertain what are the specific relations of this form. It appears in such an isolated manner in the Salt-range that from its geological position no conclusion can be drawn as to its relation to other forms, and one is restricted for such considerations to mere similarities.

A certain similarity exists between the present species and *Orth. crenistria*, Phill., but the semi-conical form of the ventral, and the entirely flat condition of the dorsal valve, are features which seem not to occur in Phillips' species, and thus the two forms will probably be different.

Other species are yet much less similar, and scarcely need a closer comparison, and thus the present species appears as a rather isolated form of uncertain affinities.

Sub-Family: *STROPHOMENINÆ.*

Genus: LEPTÆNA, Dalm. (emend. Davids.).

It is with great doubt and hesitation that I introduce this genus into the fauna of the Salt-range. The interior of the little shell which I place in this genus is absolutely unknown to me; and only the existence of a very distinct area in the smaller valve, and the typical similarity to other species of *Leptæna* like *Lept. oblonga* or *Lept. transversalis*, induce me to place this shell in that genus.

After the extremely interesting discovery of spirals in the interior of *Lept. liasina* by Mr. Munier Chalmas, I thought it indispensable for me to detect also spirals in the shell from the Salt-range, as this shell bears a great external resemblance to *Koninckella liasina*, but all my endeavours failed, and I must now believe that the Salt-range shell really possessed no spirals.

After this nothing remains for me but to place this shell either in the genus *Leptæna* or *Chonetes*, and I have put it into the first of these, on account of the development of distinct area in the smaller valve and the absence of spines along the margin of the area of the larger valve.

The only species in the Salt-range will bear the name *Leptæna indica*, Waagen. It occurs not very rarely at certain localities at the base of the compact limestones forming the middle division of the Productus-limestone.

1. LEPTÆNA INDICA, Waagen, n. sp.; Pl. LVIII, figs. 7, 8, 9.

This little shell has either a circular, or a somewhat transversely or elongately oval shape. The ventral valve is strongly inflated and convex, the dorsal one as much concave. Both valves are entirely smooth.

The ventral valve is so strongly inflated that it appears nearly semi-globose in outline. It is equally vaulted in both directions, and the curve is not stronger near the apex than near the front. The apex is not very prominent, pointed, and strongly bent over. The hinge-line is long and straight, as long or longer than the greatest breadth of the shell. Thus distinct wings are produced of a triangular shape and slightly vaulted. All along the hinge-line a narrow but distinct area extends, which is highest in the middle. Below the apex this area is cut open by a comparatively small triangular slit, of which I am not able to indicate with certainty whether it is closed by a pseudodeltidium or not. The area is mostly more or less concave. The surface of the valve is entirely smooth, and even with the lens no sculpturing can be distinguished. If the smooth epidermis is taken off, a rather coarse punctation of the shell-substance appears.

The dorsal valve is concave and follows in its curvature in every respect the curvature of the ventral one. The wings are also distinctly developed and concave. There is no distinct apex of this valve. Along the hinge-line a distinct narrow area is developed, which bears in the middle a triangular prominence, where the cardinal process is inserted. This valve also is entirely smooth.

Of the interior characters of the species nothing is known to me.

The measurements of three specimens from Katta are as follow:—

Entire length of the shell	9· mm.	9· mm.	8· mm.
Entire breadth of the shell	10· „	9·5 „	7·5 „
Length of the hinge-line	10·5 „	10·5 „	7· „
Entire thickness of the shell	4·5 „	5 „	3·5 „
Distance of the valves from each other	2· „	?	1·5 „
Apical angle of the ventral valve	110°	100°	96°

No larger specimens of this species have been observed.

Locality and geological position.—This species is restricted to a single bed at the base of the compact limestones composing the middle division of the Productus-limestone. It has been collected in this position by myself at Katta (6 sp.) and at Nursing Pohár (1 sp.).

Remarks.—It has been remarked already in the exposition of the genus that the classing of this species with *Leptæna* is rather doubtful.

As to species the silurian *Leptæna oblonga* and *transversalis* are not dissimilar, but it is not quite probable that they should be specifically identical. Another form, however, the distinction of which is very difficult, is *Productus lævis*, Davids., from the carboniferous beds of the Kashmir valley. On a first glance at the drawing one would take the two forms to be absolutely identical, and I cannot at all assert whether they are not so in reality. Of the Kashmir form, however, the dorsal side is not known, and thus it cannot be ascertained whether an area is present or not. As Mr. Davidson has put this shell into the genus *Productus*, it is most certain that he could not state the presence of an area, and thus it must remain doubtful whether the Kashmir and the Salt-range shells are identical or not. In awaiting the solution of this question from new finds in Kashmir, I have introduced the above name for the Salt-range form in a provisional way.

Family: *PRODUCTIDÆ.*

This is one of the oldest families that has been distinguished among the *Brachiopoda*, it having been founded as far back as 1846 by King; and since that time it has not undergone very great changes. Most authors have agreed in one point regarding this family, that is, to place it at the end of the *Arthropomata*, just before the *Lyopomata;* and its position in the system seems to be more certain than that of any other family of Brachiopods.

Its characters are very easy to be framed. The most striking one of all is the existence of reniform prominent ridges on the inside of the dorsal valve, a character which, in this strong and distinct development, is entirely restricted to the *Productidæ*. The nature of these ridges has been much disputed, and must be considered even now as an open question. Davidson and others were of opinion that these strange organs, in which the impressions surrounded by the ridge were taken to be the essential feature ("reniform impressions"), belonged to the vascular system, and were to be considered as strangely developed vascular impressions. In opposition to this view, the opinion was propounded by Keyserling, M'Coy, and Howse, that the prominent ridges had to be taken as the essential feature in these organs, and that these ridges served for the support of the brachial apparatus. This latter opinion has been taken up most recently by Neumayr (Neu. Jahrb. f. Min., 1883, Vol. II, p. 27); and in an able discussion he tried to prove that these organs had to be considered as brachial ridges. I must confess that I fully concur with him in all his deductions, and that I myself very strongly incline to accept Professor Neumayr's opinion; nevertheless I cannot deny that it would be very desirable that some additional proofs should be adduced, before this opinion can be considered as entirely well founded. These proofs should be deduced from a careful morphological study of the species of *Strophomena* and allied genera, in which the development of the brachial apparatus on the one hand in the direction of the *Productidæ*, and on the other hand in the direction of *Tropidoleptus* and the *Terebratulidæ*, must have taken place. I have not, at present, either the time or the materials to enter into such studies; but for the present, after Professor Neumayr's publication, it seems to me far preferable to designate these strange organs of the *Productidæ* as brachial ridges than to continue to call them "reniform impressions," as, indeed, it is not the impression which is the essential part of the organ, but the surrounding elevated ridge.

A passage in Professor Neumayr's paper, which is of very great importance, I must quote here more in detail. He says, a chief objection of Davidson's against the opinion that these ridges form part of the brachial apparatus is the existence of spiral impressions which are to be found in the ventral valve of some specimens of *Productus*, and which beyond any doubt are impressions of the spirally enrolled arms of the animal. Now, as these impressions show not the slightest accordance

with the brachial ridges, Mr. Davidson concludes that these latter cannot be taken as belonging to the brachial apparatus. "I cannot concur," says Professor Neumayr, "in this argument. The greater number of the now living Brachiopods have arms showing a double curve; and if such were, as is probable, present in *Productus*, these features (the ridges in the one and the spiral impressions in the other valve) are in no way difficult to explain; on the contrary, they indicate very accurately the direction and the manner in which the arms extended in *Productus*. They ran first along the descending, then along the re-ascending branch of the ridges, were then bent back over the descending branch and curled in a spiral coil, which caused the impression in the ventral valve. Thus, in their general shape, these arms very nearly agree with those occurring in *Terebratula* and *Waldheimia*, though in proportion and direction of the different parts certain differences exist." This deduction is of very great systematic importance.

Another very characteristic feature of the *Productidæ* consists in the cardinal process of the dorsal valve, which is mostly long and thickened at its extremity. It is generally tripartite at its upper or exterior face, and bipartite on the lower or interior one.

The ventral valve shows no very characteristic features. In *Productus* and some allied genera the valve is entirely devoid of cardinal teeth, whilst in *Chonetes* and *Strophalosia* such teeth are present. The presence or absence of these teeth can very well be made use of for the distinction of two sub-families within the *Productidæ*, of which one may bear the name *Chonetinæ*, whilst the other has to receive the name *Productinæ*.

Sub-Family: *CHONETINÆ*.

This sub-family comprises those forms which have cardinal teeth developed in the ventral valve. In connection with this character is the very general occurrence of an area in the ventral valve and a pseudodeltidium in the middle of it. None of the muscular impressions is dentritic. The greater part of the forms belonging to this sub-family are free, but some, the *Strophalosiæ*, have been fixed to foreign bodies either only in the young stage, or during the whole lifetime. One species, a *Strophalosia*, has lived parasitic in the interior of corals.

The following genera belong to this sub-family :—

1. Chonetes, Fisch. v. Waldheim, 1837. Oryct. Gouv. de Moscou, II, p. 134, pl. 26, f. 8, 9.

This genus is characterised by a long straight hinge-line and a narrow area in the ventral valve, marked off from the remainder of the shell by sharp edges, which are ornamented with a row of projecting spines. All the species are free, not sessile. Silurian to permian. (For particulars of the genus see Oehlert: Bull.

Soc. Géol. de France, 3rd sér., t. XI, p, 513; T. Young, Geol. Mag. Dec. II, Vol. X, p. 368; and Davidson, *ibid.*, p. 371.)

2. Strophalosia, King, 1844. Ann. and Mag. Nat. Hist., Vol. XIV, p. 313.

Hinge-line short; an area mostly in both valves, the margins of which are *not* provided with a row of spines. Most of the species are sessile during their younger stages of growth, or during their whole lifetime. (Devonian ?) Permian.

3. Chonetella, Waagen, n. gen.

This genus holds about the middle place between *Chonetes* and *Productus*. The cardinal teeth are rudimentary. In both valves an area is mostly present, the upper margins of which, in the ventral valve, are ornamented with spines. The brachial ridges form the commencement of a spiral. (?) Permian (Salt-range).

4. Daviesiella, Waagen, n. gen.

I create this genus for the reception of such forms as *Productus Llangollensis*, Dav., and *Prod. comoides*, Sow., which are characterised by cardinal teeth and a second pair of adductor impressions in the ventral valve. The other characters are like those of *Productus*. Mountain-limestone.

Sub-family: *PRODUCTINÆ.*

This is composed entirely of forms in which the ventral valve is without cardinal teeth, and in which the impressions of the adductor muscles are dendritic. The shells that belong to this sub-family attain far more considerable dimensions than those of the preceding sub-family, and some of the species are among the largest forms that occur in the *Brachiopoda*. Nearly all the shells of species belonging to this sub-family are free during their whole lifetime, and were not even fixed by a pedicle to foreign bodies. Only in the genus *Productus* some few species occur, which were fastened either by the entire ventral valve or by spines that project from that valve and creep root-like along corals, the stems of crinoids, or similar objects.

The genera belonging to this sub-family are the following:—

5. Aulosteges, Helmersen, 1847; Neu. Jahrb. f. Min., p. 330.

The hinge-line of these shells is long; the ventral valve has a large and high area, with a not very large pseudodeltidium in the middle. The interior of the dorsal valve is characteristic. Permian.

6. PRODUCTELLA, Hall, 1867; Pal. New York, Vol. IV, p. 153.

Hinge-line tolerably long, denticulated; ventral valve with area. Devonian.—(?) Carboniferous (Prod. sinuatus, Kon.?)

7. PRODUCTUS, Sowerby, 1812; Min. Conch, I., p. 153, pl. 68., IV, p. 15, pl. 317.

Hinge-line tolerably long, smooth, not denticulated. Ventral valve very rarely with a linear area. Internally the valves of the well-known construction. Carboniferous, permian.

8. MARGINIFERA, Waagen, n. gen.

Shell externally very much like *Productus*. Internally a thickened shelly margin extends parallel to and at a certain distance from the edge of both valves, thus causing a partition to be formed within the shell (see Pl. LXXVII, fig 6). Carboniferous (?) to permian.

It appears from this list that the number of generic divisions in each sub-family is not very large, but so much the larger is the number of species within the single genus. The sub-family *Chonetinæ* begins already in the silurian period and extends up into the permian, whilst the *Productinæ* start from the devonian and terminate also in the permian formation.

In the Salt-range not less than six of the eight genera above enumerated are represented; they are: *Chonetes*, *Strophalosia*, *Chonetella*, *Aulosteges*, *Productus*, and *Marginifera*.

Sub-family: *CHONETINÆ*.

Genus: CHONETES, Fisch. v. Waldh.

This genus has been long recognised and very generally accepted. It is in general very easily recognisable by the regular shape, the long and straight hinge-line, and a narrow area in the ventral valve of the shells belonging to it. The area is generally ornamented along its upper margin with prominent spines. On a first glance the species of *Chonetes* can be distinguished from *Productus* by a much less strongly curved ventral valve and an apex which is not at all bent over. Though this external shape is retained by the greater number of species, yet there are exceptions. There are chiefly some forms in which the spines on the upper margins of the area are not developed. It might be that in these shells, if better preserved specimens were obtainable, such spines would be detected; but in one species from the Salt-range at least it seems highly probable that the shell never possessed such spines. In other cases the shell of *Chonetes* becomes strongly vaulted, the apex much bent

over and even enrolled; and then the area under the beak becomes much concealed and the similarity to *Productus* very great.

In the interior the shells of *Chonetes* are very characteristic. In the ventral valve there are small hinge-teeth on both sides of the pseudodeltidium. The muscular impressions are mostly not very distinct, and only the adductor impressions can be well seen on both sides of a raised middle line or kind of low septum. Immediately adjoining these are large oval impressions, apparently partly muscular and partly perhaps ovarial impressions. The interior of the dorsal valve shows a small impressed or hollowed out cardinal process on both sides of which the dental sockets are situated. The muscular impressions as well as the brachial ridges are in all the species of the Salt-range at least very distinct; the latter are generally speaking rather more hook-shaped than reniform.

The dentoid muscular impressions, characteristic for all the genera of the subfamily *Productinæ*, are absolutely absent in the genus *Chonetes*.

The genus is very largely represented in the Salt-range, and some beds are filled with thousands of individuals of a single species. Not less numerous, however, than the individuals are the species, and I am able to distinguish not less than 14. When one considers that in all the formations beginning from the silurian up to the permian only about 60 species are known up to the present, the number of 14 in the beds of the Salt-range must really be taken as enormous. Also, the variation of form is much greater in these species than has been known up to the present in the genus *Chonetes*. Mons. de Koninck has distinguished five sections within the genus, *viz.:* I. *Concentricæ*, with concentric plications; II. *Comatæ*, with more than 100 smooth radial folds; III. *Striatæ*, with less than 100 but more than 30 smooth radial folds; IV. *Plicosæ*, with less than 30 smooth radial folds; and V. *Rugosæ*, with rugose radial folds. Of these groups I should think the second and third, the *Comatæ* and the *Striatæ*, should be united, as their distinction is entirely artificial, and on a first glance it is impossible to distinguish between the two divisions. The divisions, however, should be based on such external characters as would make the distinction of the single forms possible on a first glance. Thus we have for the present four divisions: I. *Concentricæ*, II. *Striatæ*, III. *Plicosæ*, and IV. *Rugosæ*. Of these four groups, only one is represented in the Salt-range—this is the *Striatæ;* but only three of the species occurring there can be placed in this group, and all the others belong to groups of forms which were not known at the time of publication of Mons. de Koninck's work. One further division has already been introduced by Davidson for the reception of *Chonetes polita*, M'Coy, and for which he created the name of "*Læves*." This division is largely represented in the Salt-range, and I count five species that belong to it. Nevertheless, there remain six more species which cannot be brought under any of the divisions hitherto adduced. They compose one more division, which contains the forms with very strong and high radiating ribs, and for which I shall introduce the designation of "*Grandicostatæ*." Thus we have got in the Salt-range three divisions of the genus *Chonetes*, *viz.*, I. *Læves*, II. *Striatæ*, and III. *Grandicostatæ*.

As regards the section *Læves*, the forms occurring in the Salt-range can be considered as forming two groups. One of them is represented by *Chonetes ambiensis*, W., a species which might perhaps be identical with *Chonetes rotundatus*, Toula., from permo-carboniferous beds of Spitzbergen, but which could not be identified on account of Toula's exceedingly bad figure. This species seems to be very nearly related to *Chonetes polita*, M'Coy, and both forms must be considered as belonging to one and the same group, which I shall call "Group of *Chonetes polita*, M'Coy." The remaining four species of the Læves are all more or less nearly related to each other, and form together one group which seems to have taken its origin from *Chonetes glabra*, Gein. (*non* Hall.), of the permo-carboniferous beds of Nebrasca. The name of the latter species having been preoccupied by Hall, I introduce for it the name of *Chonetes geinitziana*, W., and shall call this group "Group of *Chonetes geinitziana*, W."

The division "*Striatæ*" is but sparingly represented in the Salt-range, but yet the species occurring there can be distributed into three groups. There is one species, flat and finely striated, which I shall call *Chonetes squama*, W., and which seems to be most nearly related to and as belonging to the "Group of *Chonetes papilionacea*, Phill."

Another species, for which I shall introduce the name of *Chon. strophomenoides*, W., is most nearly related to the typical *Chon. variolata*, Orb., which I consider as entirely different from *Chon. variolata*, Kon. (*non* Orb.) or *Chon. granulifera*, Owen. This species will thus belong to the "Group of *Chon. variolata*, Orb." The third species of the *Striatæ* will bear the name of *Chon. compressa*, W.; it is bipartite, and thus more or less nearly related to *Chon. variolata*, Kon. (*non* Orb.) and different from *Chon. lagnessiana*, Kon. (=*Chon. hardrensis*, Pill., Dav.). What name ought to be applied to Köninck's *Chon. variolata* is difficult to decide; perhaps the name of *Chon. vishnu*, Salt, which was introduced for a carboniferous species of the Himalaya, could be made use of, or else *Chon. flemingi*, Norw. and Pratt.; provisionally I shall call this group "Group of *Chon. vishnu*, Salt."

The section *Grandicostatæ* is, as far as is known up to the present, entirely restricted to India. The six species occurring in the Salt-range belong to two different groups. The first of these is more or less nearly related to *Chon. austeniana*, Dav., from Kashmir, and two species can be distinguished within it: *Chon. semiovalis*, W., and *Chon. dichotoma*, W. The second group seems to be rather nearly related to a shell which has been described by Davidson also from Kashmir under the name of *Spirifer barusiensis*. To this group belong *Chon. squamulifera*, W., *Chon. deplanata*, W., *Chon. grandicosta*, W., and *Chon. aequicosta*, W.

Thus we arrive at the following grouping of the species of *Chonetes*:—

I.—Section: LÆVES.

a.—Group of CHONETES POLITA, M'Coy.

1.—*Chonetes ambiensis*, Waagen, n. sp.

b.—Group of CHONETES GEINITZIANA, Waagen, n. sp.

2.—*Chonetes morahensis*, Waagen, n. sp.
3.— „ *avicula*, Waagen, n. sp.
4.— „ *trapezoidalis*, Waagen, n. sp.
5.— „ *bipartita*, Waagen, n. sp.

II.—Section: STRIATÆ.

c.—Group of CHONETES PAPILIONACEA, Phill.

6.—*Chonetes squama*, Waagen, n. sp.

d.—Group of CHONETES VARIOLATA, Orb.

7.—*Chonetes strophomenoides*, Waagen, n. sp.

e.—Group of CHONETES VISHNU, Salt.

8.—*Chonetes compressa*, Waagen, n. sp.

III.—Section: GRANDICOSTATÆ.

f.—Group of CHONETES AUSTENIANA, Davidson.

9.—*Chonetes semiovalis*, Waagen, n. sp.
10.— „ *dichotoma*, Waagen, n. sp.

g.—Group of CHONETES BARUSIENSIS, Davidson, sp.

11.—*Chonetes squamulifera*, Waagen, n. sp.
12.— „ *deplanata*, Waagen, n. sp.
13.— „ *grandicosta*, Waagen, n. sp.
14.— „ *æquicosta*, Waagen, n. sp.

With regard to the apparition in time of the different species, it must be noted that the lower Productus-limestone has furnished but a single species: *Chon. ambiensis*. This seems to be very nearly related to the coal-measure species *Chon. rotundata*, Toula., whilst the latter stands in close connection to *Chon. polita*, M'Coy, from the mountain-limestone. It is beyond doubt a developmental series, which is here before us, *Chon. lævis*, Dav., from carboniferous deposits of the Himalaya might perhaps be identical with *Chon. rotundata*, Toula. All the other species of the Salt-range occur in the middle and upper divisions of the Productus-limestone. The group of *Chon. geinitziana* stands in very close relation to that American coal-measure species, and *Chon. morahensis*, W., is the form that approaches nearest that species, and is at the same time the geologically oldest form of the group that occurs in the Salt-range. All the other forms of this group have been found in the upper Productus-limestone, but a developmental connection between any of these forms and *Chon. geinitziana*, or of the forms among each other can barely be established.

All the species belonging to the section *Striatæ* occur in the middle Productus-limestone. It is very probable that the single forms stand in a developmental

connection with the typical species of the respective groups in which they have been placed.

The two groups of forms that compose the section *Grandicostatæ* can be traced with great probability from two Himalayan shells. The one group from *Chonetes austeniana*, Dav., the other from a shell that has been described by Davidson under the name of *Spir. Barusiensis*. Mr. Davidson had only a single valve of the latter at his disposal, and thus the error, that he considered this as the dorsal valve of a *Spirifer*, can easily be explained, no shell to which it could have been compared being known at the time. *Spir. barusiensis* shows, however, such a typical resemblance to the largely costate *Chonetes* of the Salt-range, that I am convinced that the shell from Kashmir is also a *Chonetes*.

The group of *Chon. austeniana* is restricted in the Salt-range to the middle division of the Productus-limestone, whilst the group of *Chon. barusiensis* has representatives in the middle as well as in the upper divisions.

I.—Section: LAEVES.

a.—Group of *CHONETES POLITA*, M'Coy.

1. Chonetes ambiensis, Waagen, n. sp., Pl. LVIII, figs. 1—6.

This little species is about semi-circular in its outline, the hinge-line being as long or a little longer than the greatest breadth of the remainder of the shell. The ventral valve is very strongly inflated, and the dorsal one just as much concave. On each side of the apex along the margin of the area of the ventral valve, mostly three, sometimes four spines are situated.

The ventral valve is, as has been said above, very strongly vaulted, and its curve is very equal and regular in both directions, only the apical region is slightly more strongly inflated than the rest of the valve, thus allowing the wings to appear slightly flattened towards both ends of the hinge-line. The apex is barely prominent, but distinctly bent over. The hinge-line is quite straight, and generally marks the greatest breadth of the shell, only rarely is the greatest breadth situated a little lower down. Between the hinge-line and the apex extends a long but narrow area, which is sometimes concave, sometimes not. It is ornamented with striæ of growth parallel to the hinge-line. In the middle there is a very large and broad triangular fissure, which is only at its upper extremity filled up by a small and short vaulted pseudodeltidium, which is, however, easily lost. On the very sharp margins of the area, which descend from the apex to both ends of the hinge-line, three to four very thin spines are situated on each side; they are, however, in none of the specimens entirely preserved.

The surface of the valve is entirely smooth, only very faint striæ of growth can be distinguished, but no large punctures.

The dorsal valve is sometimes more, sometimes less, concave, chiefly towards the middle region of the valve, but the wings in the vicinity of both ends of the

hinge-line are almost always considerably flattened. Along the straight hinge-line a narrow but very distinct area is developed, which turns its face somewhat towards the observer. In the middle there is a thick, oval, prominent knob, which bears an excavated line in the middle, and fills the deltidial fissure of the other valve; it is the external continuation of the cardinal process. This valve is also entirely smooth, with only some more strongly marked imbricating striæ of growth; nor are any larger punctures observable in it.

The internal characters of both valves are well known to me. In the ventral valve there are on both sides of the cardinal fissure small but distinct hinge-teeth, which are not supported by septa. At the upper end of the same fissure a distinct septum commences, which is highest and bifid at its upper termination, then tapers quickly and changes into a low ridge, and in this form it extends nearly half way down to the front of the valve. Not far from its upper termination two narrow, elongated deep impressions are situated, which are probably the scars of the adductors, and outside of these two very large roundish impressions can be discerned, very likely the scars of the divaricators. The whole arrangement of these impressions shows a very great similarity to the same organs in *Chonetes hardrensis* as figured by Davidson. The whole remaining interior surface of the valve is covered by rather coarse granulations, which are arranged in indistinct radial rows.

The dorsal valve has a broadly compressed, not very prominent, cardinal process, on both sides of which the dental sockets are situated. Both pairs of adductor impressions are very distinct. Between the two pairs on each side the brachial ridges take their origin. They descend in a gentle curve to more than half way from the front-margin, and then bend round towards the middle line, forming nearly a semi-circle. The middle line is not raised but excavated. The whole surface of this valve, except the muscular impressions, is covered by a rather coarse granulation, which is tolerably distinctly arranged in radial rows.

The measurements of the largest specimen known to me are as follow:—

Entire length of the shell	9 mm.
Length of the ventral valve	8 „
Entire breadth of the shell	11 „
Length of the hinge-line	10 „
Entire thickness of the shell	3·5 „
Distance of the two valves from each other	2·5 „
Apical angle of the ventral valve	146°

There exists some variation among different individuals as to comparative breadth of the shell and length of the hinge-line, the inflation of the ventral valve, and so on, but the variation is never great.

Locality and geological position.—This species is restricted to the lower division of the Productus-limestone, but there is only one locality where it occurs in great numbers and fills a whole bed with thousands of individuals, the *Chonetes* bed, as I have already quoted it several times. This locality is below the village of

Amb, and the fossils are contained in a black or brownish sand or soft sandstone, very low down in the fossiliferous series.

At other localities the species seems to be very rare. A single specimen was collected by Dr. Oldham in the lower Productus-limestone of Swás.

Remarks.—In its general form this species resembles very much four species: these are *Chonetes polita*, M'Coy, *Chon. laevis*, Dav., *Chon. rotundata*, Toula, and *Chon. palumbona*, M. & W., the first from the mountain-limestone proper, the second from carboniferous beds of the Himalaya, the third from permo-carboniferous beds of Nowaja Semlia, and the fourth from the Keskuk-limestone of Illinois. From all these the present species can be well distinguished. *Chonetes polita* remains much smaller; larger punctures are disseminated over its surface, a character which is absent in *Chon. ambiensis;* and the internal features of the dorsal valve are so entirely different that this alone can serve for a strict distinction of the two forms. *Chonetes lævis, Dav.*, has a much longer hinge-line and seems to be less strongly inflated; the apex is also far less strongly prominent. *Chon. rotundata*, Toula, appears to be a little larger than the Indian species, but it is to be regretted that Toula's figure is so insufficient that a close comparison seems barely possible. In the description Toula says that larger punctures were present, and thus it appears probable that also the species from Nowaja Semlia was different from our *Chon. ambiensis*. *Chonetes palumbona*, Meek & Worthen, is similar in size and general outline, but it exhibits a flattened apex, an obscure radial striation, and much more numerous spines along the margins of the area, and thus cannot be considered identical with our Indian shell.

b.—Group of *CHONETES GEINITZIANA*, Waagen.

2. Chonetes morahensis, Waagen, n. sp., Pl. LIX., figs. 6, 7, 8.

This is a middle-sized species of approximately semi-circular outline, the hinge-line being about as long as the greatest breadth of the shell. The ventral valve is strongly bipartite, as it bears a deep sinus in the middle which is hemmed in on both sides by broad prominent folds.

The ventral valve is rather flat, not much inflated. The curve is tolerably equal in both directions, but in the transverse direction it does not remain the same for its whole extent, as the lateral parts of the valve are considerably flattened. The apex is barely prominent and not pointed. The area is comparatively broad, vertical, but very little concave, and cut open in the middle by a large deltidial fissure. Neither the pseudodeltidium nor the cardinal teeth can be observed. Along the cutting edges, which mark off the area, the traces of five broken off spines can be observed on each side of the apex, sometimes with some additional finer ones, immediately near the apex. From the apex towards the frontal margin there extend two diverging strong, broad, rounded folds, which have a rather deep, but not broad, sinus btweeen them. Outside of these folds, towards the lateral

flattened parts of the valve in some large specimens, slight traces of a faint radial undulation of the shell can be observed.

The surface of the valve is smooth, with the exception of some imbricating striæ of growth, which appear from distance to distance. In large specimens these striæ of growth get more and more numerous towards the margin of the valve. When the shell is somewhat injured by weathering, it is seen to be composed of radially arranged fine fibres, which then give to the shell a finely radially striated appearance. Between these fibres some larger punctures can be observed with the lens; they are arranged in quincunx.

Though this species is not at all rare, yet I have not succeeded in cleaning the the dorsal valve, and thus only the ventral one is known to me.

The inside of the ventral valve is exposed in several specimens, but all of them are very much weathered, and the details of the interior arrangement cannot be observed with accuracy.

The measurements of the largest specimen known to me and of a middle sized specimen, both from Morah, are as follow:—

	I.	II.
Entire length of the shell	9 mm.	7 mm.
Height of the area	1·5 „	1 „
Entire breadth of the shell	13·5 „	11 „
Length of the hinge-line	13 „	10 „
Entire thickness of the shell	3 „	32·5 „
Apical angle of the ventral valve	145°	150°
Divergence of the two folds on the ventral valve	21°	22°

Locality and geological position.—The species commences already in the lowest part of the middle Productus-limestone, but becomes common only in the upper division of the same formation.

The former geological position is held by a specimen that I worked out of a slab of rusty calcareous rock that had been brought by Dr. Oldham from Swás, and which contained a great many species of Brachiopoda. These rusty limestones constitute a well-marked horizon towards the base of the middle division of the Productus-limestone.

All the other specimens, of which there are a great many, are contained in a slab of yellowish gray sandstone, which was collected by Mr. Wynne at Morah. The nature of the rock cannot leave much doubt as to the horizon from which it came, and it may be considered as certain that these specimens come from the upper division of the Productus-limestone.

Remarks.—The present species stands beyond any doubt in very close relation to *Chonetes glabra*, Geinitz, or, as I have called it, *Chonetes geinitziana*, as the name "*glabra*" had been already employed by Hall for a species of the devonian system in the year of 1857, whilst Geinitz's name was not given before 1866. Therefore the name of Geinitz's species from permian and carboniferous beds had to be changed. *Chon. geinitziana* is in all respects similar to the present species except in the general outline which is more transversely trapezoidal, and in the development of the sinus

of the ventral valve which is broader and less deep, whereby it arises that the two folds which extend from the apex diverge at an angle of about 70°, whilst the angle enclosed between them is only 21°—22° in the species hereunder consideration.

Thus, though it is highly probable that there exists a certain developmental connection between the two forms, yet it seems necessary to distinguish the Indian shell under a proper specific designation.

I know of no other species which could be more closely compared to the present one.

3. Chonetes avicula, Waagen, n. sp., Pl. LIX., fig. 5.

This is a middle-sized species of a nearly rectangular or squarish outline, having a slightly vaulted ventral and a concave dorsal valve, the former with two radiating folds. The margins of the shell are not in one plane as in other species, but the lateral parts are depressed, and the frontal part bent up in the direction of the ventral valve, as it appears on the drawing, Pl. LIX., fig. 5f.

The ventral valve is nearly flat, and very little vaulted. Its curve is regular, but very small in the longitudinal direction. The curve is somewhat more considerable in the transverse direction, but here restricted to the median part of the shell, whilst the lateral parts, chiefly in the vicinity of the hinge-line, are considerably flattened. The apex of the valve is barely prominent, not pointed and not bent over. The area is comparatively large and strongly reclining, cut open in the middle by a not very large triangular fissure, which is perfectly filled up by the cardinal process of the other valve. A pseudodeltidium cannot be distinguished. The very sharp margins, by which the area is limited off from the other face of the valve, are ornamented by three spines on each side of the apex, but in the majority of specimens every trace of these spines has been destroyed. From the apex down to the front extend two strongly prominent rounded folds, which have a tolerably deep sinus between them. Outside of these folds the valve is depressed and bent down, so that the lateral margins make a gentle wave downward in the direction of the dorsal valve. The front margin on the contrary is again bent up in the direction of the ventral valve, notwithstanding the sinuation which it bears in the middle.

The dorsal valve is concave and follows in every particular the curve of the opposite valve. The apex is not at all prominent but also hollowed out. The valve bears a narrow but distinct area, which is interrupted in the middle by a prominent knob, the outward continuation of the cardinal process. The valve shows in the middle a not very prominent, broad, rounded fold, which is limited on both sides by not very broad rounded furrows. The lateral parts are strongly bent up, and flattened only near the hinge-line. In some specimens it appears as if a sculpturing of some few radiating lines were present, but these are very faint and barely visible even with a lens.

The interior structure of this species is not known to me. The surface of the

shell is entirely smooth, and even the imbricating striæ of growth are scarce and faint. Larger punctures seem to be present, but are very indistinct.

The measurements of a specimen from Khura are as follows :—

Entire length of the shell	7·5 mm.
Length of the dorsal valve	7 „
Entire breadth of the shell	10 „
Length of the hinge-line	8·5 „
Entire thickness of the shell	3 „
Distance of the valves from each other	1 „
Apical angle of the ventral valve	155°
Divergence of the two folds on the ventral valve	30°

Locality and geological position.—This species has been found by me at a single locality,—this was in the section near Khura, where it occurred not very rarely in the upper division of the Productus-limestone. I procured there four specimens, all duplicates.

Remarks.—The present species is again more or less nearly related to *Chon. geinitziana* and the species previously described. From both it can be well distinguished by its nearly squarish outline and the undulating shell margin.

There is no other species known to me to which the present one could be more particularly compared.

4. Chonetes trapezoidalis, Waagen, n. sp., Pl. LIX., figs. 3, 4.

Of this rather small species only ventral valves are known to me. They present a more or less trapezoidal outline, the greatest breadth of the shell being marked by the hinge-line. From the apex to the front-line there extend two strongly prominent and strongly diverging folds. The frontal margin is strongly indented.

The ventral valve is tolerably strongly vaulted, chiefly in the longitudinal direction. Its curve is regular, and the greatest inflation is situated about the middle of the valve. Transversely the curve is less strong, and at the same time less regular: the lateral parts are distinctly flattened, whilst the middle is considerably elevated. The apex is somewhat prominent, bent over and pointed. The area is not clearly visible and cannot be entirely cleaned on account of the smallness of the specimens and the hardness of the rock in which they are contained. As far as it can be made out, the area seems to be tolerably large, flat, only a little concave towards the apex, and cut open in the middle by a tolerably large deltidial fissure. The very sharp upper margins of the area are ornamented with three spines on each side of the apex. These spines are always broken off. The surface of the valve appears very distinctly characterised by the two very strong diverging folds extending from the apex to the frontal margin. Between them there is a deep and very broad sinus, whilst outside there are other not very high or distinct radial folds. They are three to four in number. The margins of the valve are all in one plane, and the frontal margin shows a deep sinuation.

The surface of the valve is apparently entirely smooth, and only very faint striæ of growth can be observed. The preservation of the surface is not sufficiently clear to allow it to be stated whether larger punctures were present or not.

The dorsal valve of this species is not known to me.

The largest specimen that has been observed up to the present shows the following measurements:—

Entire length of the shell	6	mm.
„ breadth of the shell	10	„
„ thickness of the shell	2	„
Apical angle of the ventral valve	122°	
Divergence of the two folds	52°	

Locality and geological position.—I detected this species in the same slab of sandstone, coming from the upper Productus-limestone of Morah, in which *Chonetes morahensis* was contained in great numbers. The present species is, however, very much rarer than the other one; for whilst the slab contained a great number of specimens of *Chonetes morahensis*, I detected not more than two specimens of the present species in it.

Remarks.—The form here under consideration seems to be most nearly related to the species with which it is associated, this is *Chon. morahensis*. The differences from that species consist in the trapezoidal outline, in the broader median sinus of the ventral valve, and the greater divergence of the two prominent folds, and in the smaller number of species along the margins of the area.

Chon. geinitziana is yet more widely different from the present species than *Chon. morahensis*.

5. Chonetes bipartita, Waagen, n. sp., Pl. LIX., figs. 1, 2.

This is a comparatively large species, with a transversely oval outline, having a slightly inflated ventral and a concave dorsal valve, with a longitudinal angular impression along the middle of the ventral valve.

The ventral valve is rather flat, only a little vaulted. The curve is very regular in the longitudinal direction, but less so transversely, where the lateral parts of the valve are considerably flattened. The apex is very prominent, pointed, and distinctly bent over. It overhangs a tolerably broad vertical area, which is a little concave, and cut open in the middle by a very large deltidial fissure. The surface of the valve is ornamented with two broad rounded folds or protuberances, separated from each other by a very narrow sinus, which appears almost as if cut in with a knife. The sinus commences only at a certain distance from the apex. The condition of preservation of the only ventral valve that exists in the Salt-range collection is such that it remains doubtful whether the sharp edges limiting the area were ornamented with spines or not. It appears to me as if there were points of insertion of eight spines on each side of the apex, but I cannot be certain on the point.

The surface of the valve is perfectly smooth, with the exception of some imbricating striæ of growth, which are, however, not very distinct. With the lens a great number of larger punctures, which seem to be rather irregularly disseminated, can be seen. The interior of the ventral valve is not known to me.

The dorsal valve is almost entirely flat and only very slightly concave. In the middle it bears a narrow prominent longitudinal fold. The external side is, however, in the specimens at my disposal, nearly quite covered up by rock-matter, and it is chiefly the internal side which is well preserved. The cardinal process is prominent, conical, and flattened on the interior side: interiorly at its origin a distinct circular groove is excavated. The dental sockets on both sides of the process are long, narrow, and slit-like. The muscular impressions are very distinct. The outer and larger pair of adductors forms large reniform impressions in deep grooves below the dental sockets. The smaller pair is situated on a slightly raised platform, on both sides of a low septum originating between these impressions, and extending a short distance towards the front. The brachial ridges are low but distinct: they originate at the lower margin of the larger pair of muscular impressions, and turn in a gentle curve round towards the septum. The granulation, which is a prominent feature in other species of *Chonetes*, is but little developed in this one, though it is not entirely absent as would appear from the figure.

The measurements of a ventral valve from Khund-Ghat are as follows:—

Entire length of the shell	12	mm.
Height of the area	2	„
Entire breadth of the shell	16	„
Length of the hinge-line	12	„
Entire thickness of the shell	4	„
Apical angle of the ventral valve	120°	

Locality and geological position.—The species is very rare in the Salt-range, having only been found there up to the present at a single locality. It was Mr. Wynne who collected two specimens of it, one ventral and one dorsal valve, in the upper Productus-limestone of Khund-Ghat.

Remarks.—The present species seems to be further removed from the species described previously than the latter from each other. Nevertheless, I think also the present species can be added with safety to the group of *Chon. geinitziana*, like the others, but we must trace its relation not from *Chon. trapezoidalis*, but from *Chon. morahensis* Whilst the group of forms, to which *Chon. avicula* and *Chon. trapezoidalis* belong, is characterised by two radial folds, which become more and more apart from each other, *Chon. bipartita* is probably a member of another line of development, which also starts from *Chon. morahensis*, but in which on the contrary the two folds more and more approach each other.

Thus *Chon. morahensis* must be chiefly compared to the present species. It is easily distinguishable by its broader median sinus and different general outline.

II.—Section: STRIATÆ.

c.—Group of *CHONETES PAPILIONACEA*, Phill.

6. Chonetes squama, Waagen, n. sp., Pl. LXI, figs. 1, 2, 3.

The shell here under consideration is of a middle size, quite flat, of a transversely oval or somewhat trapezoidal outline, with a very fine radial striation.

The ventral valve is quite flat, barely vaulted in any direction. The apex is not prominent and not incurved, the area is very narrow, nearly linear, and, as far as can be seen, devoid of spines along its upper margins. The deltidial fissure is small. The outside of this valve is, however, not known to me, as only one specimen, of which the inside only is exposed, is accessible to my observation. Small cardinal teeth are situated on both sides of the deltidial fissure. Along the median line from near the apex a narrow elongated impression extends for about one-third of the length of the valve, hemmed in on both sides by elevated ridges. It is somewhat broader at its upper end and gets narrower towards its lower termination. On either side of these ridges bordering the median impression large oval impressions extend; they are however rather flat and not very strongly marked. These large impressions are beyond doubt the divaricator scars, but whether the median impression is due to the adductors remains doubtful, as it is too narrow to distinguish whether it is longitudinally divided in two or not. The whole inside of the valve is, like the outer side, covered with a very fine radial striation; and one can count considerably more than one hundred striæ along the margin of the valve. But while the striæ on the outside of the valve are smooth, those on the inside are finely papillate, which is only visible with a very powerful lens. The striæ augment more often by bifurcation than by intercalation.

The dorsal valve is also nearly quite flat, and only in the apical region is it a little impressed. It has a distinct linear area, which in the middle is interrupted by a slightly prominent knob, the external continuation of the cardinal process. The surface of the valve is covered by very numerous radiating striæ which augment mostly by bifurcation. If examined with a powerful lens, they show exactly the same characters as have been figured of *Chon. papilionacea* by Mr. Davidson. When the outermost layer of the shell is well preserved, the same fine scaly striæ of growth and the same sparingly distributed round orifices on the top of the striæ are observable as in *Chon. papilionacea*. This outer shell layer is, however, preserved only in very few and small patches. The greater part of the specimens at my disposal are deprived of this outermost layer, and then between the single striæ rows of oval grooves appear, exactly as on the left side of Davidson's figure. These grooves are, however, not on the internal cast, but on the interior shell layer.

The interior side of the dorsal valve can be well seen on two specimens. The cardinal process is barely at all prominent, strongly excavated, lamellar and bent

up. On both sides of it distinct dental sockets are situated. They are limited below by prominent, rounded ridges, which directly join the lateral parts of the cardinal process and separate the dental sockets from the impressions of the outer and upper pair of adductors. These latter are deep, very distinct, large and of an oval shape. Not far from the cardinal process a low median septum originates. It extends to not very far from the frontal margins. On both sides of this septum, not far from the cardinal process, two elongated grooves can be distinguished, which are evidently the scars of the interior pair of adductors. The brachial ridges are situated between the two pairs of adductor impressions, but they are very indistinct in this species; two oval slightly raised spaces can be distinguished, but the exact shape of the ridges cannot be stated. Except the muscular impressions, all the remaining inner surface of the valve is covered by a fine granulation which is distinctly arranged in radial rows.

The measurements of an isolated dorsal valve are as follow:—

Entire length of the shell	12	mm.
„ breadth of the shell	20	„
Length of the hinge-line	16	„
Entire thickness of the shell	1	„

The specimen of which the measurements have been given is the largest one known to me.

Locality and geological position.—The species occurs in a single piece of rock brought by Mr. Wynne from Katwáhi. The rock is much decomposed by weathering and consists of a fine yellowish-red ferruginous oolite, a rock which has never been found by me *in situ*. Also Mr. Wynne only found the fragment among the debris of the Productus-limestone. Probably the oolitic nature of this rock has only become visible through the action of weathering; and it appears highly probable that this piece came from the middle Productus-limestone. The lower Productus-limestone is not well developed in the vicinity of Katwáhi, and is there mostly represented by lavender-coloured clays. The upper Productus-limestone of the same region is entirely composed on the other hand of yellowish-gray sandstones, and thus there remains for this ferruginous oolitic limestone no other division but the middle one from which it probably came.

The piece of rock in question is entirely filled with the shells of this *Chonetes*, and no other species is contained in it.

Remarks.—Though the spines along the margins of the area have not been detected up to the present on the form here under consideration, yet I think it most probable that the species will have to be considered as a rather near ally of *Chon. papilionacea*.

I did not arrive immediately at this way of considering the matter, but for a long time was very much in doubt whether this shell should not rather be transferred to the genus *Strophomena*. After a long deliberation, however, I thought it most prudent to consider the shell as a *Chonetes*, as the interior characters, though not quite

identical with other species of *Chonetes*, can yet be most naturally brought into accordance with that genus. After I had thus come to the conclusion that the present shell was a *Chonetes*, the most natural grouping seemed to be to class it with *Chon. papilionacea*, Phill., as this is the only species which is similarly finely striated and possesses similarly flat valves, and in which the minute sculpture is absolutely identical. Though *Chonetes squama*, W., thus seems to be most nearly allied to, yet it cannot be considered identical with Phillips's species. The chief differences consist in a shorter hinge-line and smaller area of the Indian shell. Also the internal characters seem to be different, but these are very imperfectly known in *Chon. papilionacea*.

Of other species, none can be compared more particularly to the present one.

d.—Group of *CHONETES VARIOLATA*, Orb. (sens. strict.)

7. Chonetes strophomenoides, Waagen, n. sp., Pl. LVIII, fig. 10.

This is a comparatively large species of somewhat transversely rectangular outline, the greatest breadth of the shell being at the hinge-line. The shell is but little inflated, and is provided in the middle with a broad but not very deep sinus.

The ventral valve is in some specimens rather flat, in others somewhat more inflated. The curve is in neither direction quite equal and regular. Longitudinally the shell appears rather flattened in the apical region, whilst not far from the front it bends more strongly down and shows, chiefly in some specimens, a rather bold curve. Transversely the curve is very regular in the middle region of the valve, and flattened only on the lateral parts, chiefly in the vicinity of the hinge-line where distinct wings are developed. The apex is not at all prominent, not pointed, and not bent over. The area is quite flat and narrow, cut open in the middle by a very small deltidial fissure. The very sharp margins that limit the area above are ornamented by four oblique spines on each side of the apex, which are, however, not visible on every specimen.

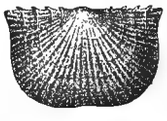


Fig. 16, *Chonetes strophomenoides*, W., n. sp., ventral valve with partly preserved marginal spines, natural size, from the lowest beds of the middle Productus-limestone of Swás.

The broad median sinus, which is developed on this valve, commences only at a short distance from the apex, and extends down to the front. The whole surface of the shell is covered by a fine radial plication, which augments mostly by bifurcation. On the margin of the valve one counts 8 to 10 striæ in the space of 5 mm., and thus 60 to 80 striæ on the whole valve. The spaces between the striæ

are remarkable for the very large punctures they bear, which are easily visible to the naked eye on certain specimens. But some of these punctures are also disseminated on the top of the striæ.

The dorsal valve is flatly concave, with a slight prominent median fold and deepened spaces on each side of it. It is very nearly approximated to the ventral valve, and the space which remains between the two is very small; towards the margins the two valves are so firmly pressed against each other that they cannot at all be distinguished. The sculpture of this valve is somewhat different from that prevailing on the other valve, the radial striæ being rather coarser, less distinctly dichotomous and somewhat wavering in direction, which latter circumstance is caused by roundish grooves placed between the ribs causing a very indistinct barely perceptible concentric sculpture to be formed. The puncturing is less distinct in this than in the other valve.

Of the internal characters but little is known to me. In the ventral valve the cardinal teeth on both sides of the deltidial fissure can be tolerably well distinguished in one specimen, whilst in the same specimen it can be seen that the cardinal process of the dorsal valve is comparatively long and very narrow. Of the other internal characters nothing is known to me.

The measurements of a specimen from Swas are as follow:—

Entire length of the shell	13	mm.
Length of the dorsal valve	12	„
Entire breadth of the shell	22	„
Length of the hinge-line	24	„
Entire thickness of the shell	4	„
Distance of the valves from each other	1·5	„
Apical angle of the ventral valve	? 120°	

Locality and geological position.—This species was contained in a single piece of rock brought by Dr. Oldham from Swás. Three species of Brachiopoda were contained in this rock: *Chonetes compressa*, W., in very great numbers, the present species, somewhat less numerously, and one species of *Strophalosia*, in a few specimens. The rock is a very hard, sandy, somewhat micaceous limestone of a rusty colour, and comes beyond any doubt from the limits between the middle and upper division of the Productus-limestone.

Remarks.—The present species is without the slightest doubt most nearly related to *Chonetes variolata*, Orb., and I would be very much inclined to consider the two shells as identical; if not, according to d'Orbigny's drawing, the South American form would possess a finer and more regular radial striation than the specimens from the Salt-range. The coarse punctation, to which the name alludes, is equally well developed in the Indian and in the American shell. Thus *Chonetes strophomenoides*, W., will probably have to be considered as a representative form or geographical variation of *Chonetes variolata*, Orb.

Chonetes variolata, Kon. (*non* Orb.) is something entirely different, and cannot be compared with the present species.

Of other species, one form of the genus *Productus* must be taken into comparison, and this is *Productus sinuatus*, Kon., of which chiefly the dorsal view shows a certain similarity. The sculpture of the dorsal valve of *Productus sinuatus* and *Chonetes strophomenoides* is nearly identical, though the concentric sculpture is slightly more distinct in Koninck's species. Also the ventral valve has a small area in that species of *Productus*, but beyond this the similarity does not extend. The curvature of the ventral valve and the disposition and direction of the spines near the areal margin are entirely different, and there remains no doubt that the two forms must be considered as distinct, even if one were inclined to put the *Productus sinuatus* into the genus *Chonetes*.

e.—Group of *CHONETES VISHNU*, Salter.

8. Chonetes compressa, Waagen, n. sp.

This is a rather small species, with very flat valves, which are so close together that scarcely any no room remains between them. The ventral valve bears in the middle a low sinus, and the radial striation of both valves is limited to the median parts, whilst the lateral parts remains entirely smooth.

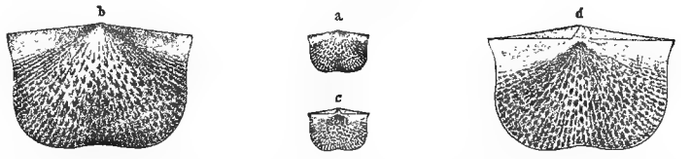


Fig. 17. Chonetes compressa, Waagen, n. sp. Specimen from the lowest beds of the middle Productus-limestone of Swás: *a*. ventral valve, natural size; *b*. the same enlarged; *c*. dorsal view, natural size; *d*. the same enlarged.

The ventral valve is nearly quite flat, barely perceptibly vaulted, and appears very much like a fish's scale. Only the median part is slightly elevated, and in the middle again impressed, thus forming a broad but very flat sinus. The lateral parts are distinctly flattened and form well distinguishable wings, which are at the same time devoid of a radial striation. The apex is very little prominent, pointed and not bent over. Below it there extends a very narrow flat reclining area, interrupted in the middle by a narrow deltidial fissure. The margins which limit the area above are very sharp, but in none of the specimens at hand can the spines, which are probably situated on them, be distinguished. The hinge-line is long and straight, and marks the greatest breadth of the shell. The sinus does not commence immediately on the apex but a little distance from it; but immediately at the apex commences the fine radial striation of the shell, which is very characteristic in this species and which covers the sinus and the elevated parts of the shell adjoining it, but is absent on the lateral wings. The striation is extremely fine, and there are four to six striæ in the space of one millimeter. The single striæ are distinctly swollen from distance to distance, where rather thick spines are placed on them, which follow approximately the direction of the shell surface,

pointing towards the margin of the shell. These spines were hollow tubes, as can be distinctly seen on their broken ends, but none of them is completely preserved on any of the specimens at hand. These spines were largest and thickest just in the centre of the valve, and from there both towards the apex and the margins of the valve they rapidly diminish in size.

The dorsal valve is very flatly concave, the apex not prominent, with a linear area along the straight hinge-line. From the apex, comparatively strong prominent folds start towards the lateral margins, thus marking off the lateral wings. The space between these two folds is most deeply impressed, whilst the wings are rather flattened. In the vicinity of the frontal margin a very slightly indicated median fold can be distinguished. The sculpture consists also in this valve of a fine radial striation, but it is in every respect the reverse from that of the other valve. Where there are striæ in the other valve are furrows in this one, and instead of the spines of the other valve we find deep grooves disseminated along the furrows.

Of the internal characters of this species nothing is known to me.

The measurements of two specimens, No. I, a duplicate, and No. II, a ventral valve only, are as follows:—

	I.	II.
Entire length of the shell	6 mm.	6·5 mm.
Length of the dorsal valve	5·5 „	?
Entire breadth of the shell (along the hinge-line) . . .	10 „	11 „
„ thickness of the shell	1 „	1 „
Distance of the two valves from each other	0·5 „	?

Locality and geographical position.—This species was present in great numbers in the same slab of rusty sandy limestone which contained the specimens of *Chonetes strophomenoides*, W., described previously. It must also be considered as coming from the lowest part of the middle division of the Productus-limestone.

Remarks.—This species belongs to a group of forms for which no proper name is available, though the geologically oldest form of the group is very well known to palæontologists. In the mountain-limestone the group of the devonian *Chonetes hardrensis*, Phill., begins to be split up into two series of forms, one with a median sinus in the ventral valve, the ancestor of the form here under consideration, and another without such a sinus: *Chon. Lagnessiana*, Kon. and allies. In the mountain-limestone proper, it must be admitted, this splitting up is not yet perfect, and the form with a sinus just begins to appear; but later on the sinuated forms become of very great importance and in the coal-measures are by far predominating. Starting from such considerations it seems to be strongly desirable to have a proper specific name for the form in the mountain-limestone in which a sinus is well developed, and which has been so excellently figured by Count Keyserling in the Geology of Russia, or by Mons. de Koninck in his monograph of the genus *Chonetes*. Perhaps this form could be identified with *Chonetes vishnu*, Salt., from carboniferous beds of the Himalaya, and this name be adopted for

it; or perhaps also *Chonetes flemingi*, Norw. and Pratt., could prove to be identical, though this comes from the upper Coal Measures of America.

That the sinuated form was not identical with *Chonetes variolata*, Orb., as was formerly advocated, has been admitted by Koninck himself in his monograph of the fossils from Bleiberg.

The species described here under the name of *Chonetes compressa*, W., is very easily distinguishable from all the sinuated forms that have been described up to the present, by its smooth wings and the comparatively large spines that are clustered together in the centre of the ventral valve.

III.—Section: GRANDICOSTATÆ.

f.—Group of *CHONETES AUSTENIANA*, Dav.

9. Chonetes semiovalis, Waagen, n. sp., Pl. LXI., fig. 5.

In its general characters the present species still approaches very nearly the "*Striatæ*," as besides the larger plications of the shell a very fine barely perceptible radial striation also exists. The outline of the shell is transversely oval, the hinge-line being shorter than the greatest breadth of the shell. The ventral valve bears a not very broad median sinus.

The ventral valve is but little inflated, very regularly and equally vaulted in both directions, only the lateral parts are slightly flattened in the vicinity of the hinge-line. The apex is slightly prominent, pointed and strongly bent over. The area is rather narrow, flat and slightly concave in the middle. The deltidial fissure is very large. The upper margins of the area are very sharp and ornamented with seven spines on each side of the apex. The median sinus of the valve commences at the very extremity of the apex. It is not very broad, but rather deeply sunk in and rounded in its depth, not sharply cut in. It is bordered on both sides by high, broad, rounded folds. Otherwise the sculpture of the shell consists of numerous, not very high rounded radiating costæ, which are often dichotomous, and rather unequal in strength, there being six within the sinus and about eight on each lateral part. All over the valve there are disseminated a very great number of large punctures which can be seen even with the naked eye. They are arranged irregularly in radial rows, the arrangement causing the formation of a very fine radial striation which is very characteristic for this species.

On the whole, however, the sculpture is somewhat variable. The radial plications, which I have described above, become sometimes very weak and barely distinguishable, so that the sculpture of the valve then only consists of the median sinus and the high folds on both sides of it. But even then the species can easily be recognised by the large punctures and the fine radial striation that is produced by them.

The dorsal valve of this species is not known to me, and nothing could be observed also of the internal characters of the species.

The measurements of a specimen from Morah are as follow :—

Entire length of the shell	13	mm.
Length of the dorsal valve	11	„
Entire breadth of the shell	18	„
Length of the hinge-line	16	„
Entire thickness of the shell	5	„
Apical angle of the ventral valve without the wings	114°	

Locality and geological position.—The species is not very rare in the middle Productus-limestone of Morah, where it occurs associated with *Chonetes morahensis*. Some four specimens from there are known to me. Another specimen was collected by myself at Khura in the topmost beds of the middle Productus-limestone, and one specimen was brought by Mr. Wynne from Khund Ghat, but the exact bed it came from is not known.

Remarks.—The present species is very nearly related to *Chonetes austeniana*, Dav., and on a first glance one might consider both identical, but on a close comparison some difference can be traced, which makes a distinction of the two desirable. In the species from Kashmir the hinge-line is comparatively longer, the radial plications fewer and broader, and the median sinus of the ventral valve narrower than in the Salt-range species. Also the fine radial striation, which is so very characteristic in *Chonetes semiovalis*, seems to be absent in *Chonetes austeniana*, Dav. It thus seems to me perfectly justifiable to distinguish the two specifically.

Another form to which the present species seems to be very nearly related is *Chonetes morahensis*, W., which has been described above. In this form, however, the radial plication, as well as the fine radial striation, is not developed to the same extent as in *Chonetes semiovalis:* the general outline is also very different, it being well rounded in *Chonetes semiovalis* and nearly trapezoidal in *Chonetes morahensis*. It needs only a comparison of the figures of the two species to see these differences.

10.—Chonetes dichotoma, Waagen, n. sp., Pl. LXI., fig. 4.

This is a middle-sized species of transversely trapezoidal outline, having a hinge-margin which occupies the greatest breadth of the shell, and a but little inflated ventral valve. This latter bears a broad median sinus and fine radial plications which show a distinct bundling.

The ventral valve is not strongly arched, but its curve is somewhat more considerable in the longitudinal than in the transverse direction; chiefly the lateral parts in the vicinity of the hinge-line are considerably flattened, thus forming a kind of wings. The apex is little prominent, pointed and well bent over: it overhangs a distinct narrow area which is entirely flat, not concave, and is cut open in the middle by a not very large deltidial fissure; along its upper very sharp margins it is ornamented by about five spines on each side of the apex. Of the spines, however, only the roots are preserved. Immediately at the apex of the valve there begins a broad sinus, which is deepest and broadest in the vicinity of the front. It is limited

on both sides by broadly rounded prominences. Besides this sculpturing the valve is covered all over by a fine radial plication, which is simple within the sinus and on the flattened lateral wings, and distinctly bundled on the prominences that border the sinus on both sides. There are about six such fine plications within the sinus, and about as many on each lateral wing; on each prominence, however, three broad bundles can be distinguished, each of which is composed of two to three ribs. Concentric striæ of growth cross over these radial plications but they are very faint.

The dorsal valve is not deeply but very equally concave, and only the lateral parts in the vicinity of the hinge-line are considerably flattened, forming distinct wings. There is a very distinct narrow area, quite straight, and interrupted in the middle by a thick cardinal process. This valve also is covered by a fine radial striation, which becomes coarser in the deep excavations corresponding to the prominences of the other valve.

The minute structure of the shell in this species shows also a great many large punctures, arranged indistinctly in radial rows.

Of the internal characters of this specie nothing is known to me.

The measurements of a specimen from Katwáhi are as follow:—

Entire length of the shell	11	mm.
Length of the dorsal valve	10	„
Entire breadth of the shell (at the hinge-line)	16	„
„ thickness of the shell	5	„
Distance of both valves from each other	3	„
Apical angle of the ventral valve, without the wings	82°	

Locality and geological position.—The only specimen of this species that is known to me was collected by Mr. Wynne at Katwáhi, but the bed it came from is not exactly known. From the preservation of the specimen it appears probable that it came from the middle division of the Productus-limestone.

Remarks.—The present species is very nearly related to the preceding one and can be distinguished chiefly by its different general outline, the broader sinus of the ventral valve and the absence of the fine radial striation, characteristic for the preceding species.

The present species agrees pretty well with *Chon. austeniana* in its general outline, but it has a much broader median sinus and a fine radial plication which is absent in Davidson's species. Thus it seems that the shell here under consideration represents a well distinguishable form which deserves a proper specific designation.

g.—Group of *CHONETES BARUSIENSIS*, Dav., sp.

Chonetes squamulifera, Waagen, n. sp., Pl. LX., figs. 1—4.

This species is of a middle size and somewhat trapezoidal outline, the greatest breadth of the shell being situated at the hinge-line. The ventral valve is rather

strongly inflated, provided with a very broad sinus, and ornamented with strong radiating folds which are never dichotomous.

The ventral valve is very equally curved, chiefly in the longitudinal direction. Transversally it appears flattened or impressed in the middle, and the lateral parts are distinctly flattened, forming small triangular wings. The apex is prominent, pointed, and strongly bent over. It overhangs a broad slightly concave area, which is cut open in the middle by a very large deltidial fissure. The upper sharp margins of the area are provided with four spines on each side of the apex. The very broad sinus of this valve begins immediately at the apex, which appears in consequence somewhat flattened. It is limited on both sides by highly elevated broadly rounded folds, which also commence at the apex. On these general features of sculpture the radial plication is distributed. Within the sinus are generally about six rather fine folds, whilst on the elevated parts of the shell, on both sides of the sinus, three very strong and thick folds follow, which are again succeeded by much smaller ones on the lateral wings. These latter are, however, often very indistinct or even entirely absent.

The minute surface sculpture of this valve is very peculiar. Under the lens, the whole surface appears as if covered with very small scales, which are very irregularly arranged and directed not towards the shell margin, but upwards towards the apex of the valve. These scales seem to be in a certain connection with the striæ of growth, and are probably a strange modification of them; though observed in most specimens, they are not always developed in the same degree, and it seems that this circumstance depends upon the more or less complete preservation of the shell surface. If the shell is somewhat worn by weathering, the large punctures which occur on most species of *Chonetes*, appear also in this one in great numbers. They are sometimes indistinctly arranged in radial rows. In this species they were evidently *not* in connection with hair-like spines on the shell surface.

Of the internal characters of the ventral valve nothing can be observed, except the existence of two well developed cardinal teeth, which are fastened to the hinge-line on both sides of the deltidial fissure.

The dorsal valve can be but rarely observed. It is rather deeply concave and in every respect the reverse of the other valve; it bears two deep excavations where the elevated folds are on the other valve, and each elevated radial plication of the ventral valve is here represented by a more or less deepened radial furrow. The lateral wings are flattened and slightly hollowed out. The valve is provided with a very distinct narrow area, which is interrupted in the middle by a strong cardinal process.

In the only specimen of the dorsal valve with its outer side accessible to observation, I cannot observe the fine scales with which the other valve is covered; but the large punctures, which seem to be somewhat more scarce than on the other valve and are arranged very regularly in radial rows, are very distinctly visible.

The inner side of the dorsal valve is most beautifully exposed in a specimen from Jabi. The cardinal process is short and little prominent, and at the sides of it the dental sockets are situated. It is somewhat excavated on its inner side. The two pairs of adductor impressions are very distinct. The outer pair is large, oval, and situated in deep grooves, which are limited on both sides by comparatively high folds. The inner pair is much smaller, narrowly elongated, and very deeply impressed, rather far apart. A short but well developed septum originates at the lower extremity of these latter impressions. The brachial ridges are large but very faint, and encircle an oval space. Nearly the entire inner surface is covered with irregularly disseminated little spines.

The measurements of the largest specimen known to me from Jabi (No. I) and of a somewhat smaller specimen from Khura (No. II) are as follow :—

	I.	II.
Entire length of the shell	10·5 mm.	8 mm.
Length of the dorsal valve	8·5 „	7 „
Entire breadth of the shell	15 „	12 „
„ thickness of the shell	5·5 „	4·5 „
Distance of the two valves from each other	?	2 „
Apical angle of the ventral valve, without the wings	76°	83°

Locality and geological position.—This is one of the more common species of *Chonetes* occurring in the Salt-range, and it extends through the middle and upper divisions of the Productus-limestone.

In the lower region of the middle division the species has been found by myself in the section at Khura (two specimens), and in the same section two specimens were detected by me in the top beds of the middle division. At Káfirkot, trans-Indus, the species is tolerably common in the middle region of the middle division; I collected there five specimens, whilst Mr. Wynne, at a spot somewhat north of my locality, obtained five specimens more.

In the upper division, I found the species west of Khura; in the lower region of the division (seven specimens), and in the upper region in the Cephalopoda bed of Jabi (five specimens).

Remarks.—If *Spirifer barusiensis*, Dav., might really be considered as the ventral valve of a *Chonetes*, then the present species would be very nearly related to Davidson's form. Nevertheless I would not consider the two shells as specifically identical. The form from the Himalaya is just twice as broad as it is long, and the lateral wings are very large and pointed; while, as regards size the whole shell is considerably smaller. In *Chonetes squamulifera* on the contrary, the length is never less than two-thirds of the breadth, the wings are much smaller and less pointed, and it attains a much more considerable size. Thus I think the two shells must be considered as belonging to two different species.

Another species for comparison is *Productus robertianus*, Kon., from permian beds of Spitzbergen. As the dorsal face of this shell is not known, the possibility of its being a *Chonetes* is yet an open question. In the description, Mons. de

Koninck compares this species also to the ventral valve of a *Spirifer*. It can, however, be easily distinguished from our *Chonetes squamulifera* by its smooth and narrow sinus and its bifurcating ribs.

Of other forms, I do not know any which could be compared more closely with the present species.

12. CHONETES DEPLANATA, Waagen, n. sp., Pl. LX., figs. 5, 6.

This species is very nearly related to the preceding one, and differs from it chiefly by its strongly flattened valves and the occurrence of dichotomous ribs.

The ventral valve is but very little vaulted in every direction. Its curve is very regular longitudinally, but transversely the valve appears impressed in the middle by the presence of a very broad sinus, and the lateral parts form rather large flattened wings. The apex is slightly prominent, pointed, and but little bent over. The area is tolerably large and flat, cut open in the middle by a large deltidial fissure. Along its upper very sharp margins, three spines can be observed on each side of the apex. The hinge-line is somewhat longer than in the preceding species, and thus the lateral wings are more prominent and more strongly pointed. The deep and broad median sinus of the valve commences directly at the apex. There are three to four fine radial ribs within the sinus. On both sides of the sinus the shell forms highly prominent broad folds, each of which is ornamented by three, mostly dichotomous, strong radial ribs. The minute sculpture of the shell is squamose or scaly as in the preceding species.

The dorsal valve bears a very distinct narrow area and is flatly concave, forming in every detail the reverse of the other valve. This valve is not sufficiently well preserved for observation of its minute surface sculpture.

Of the interior characters of this species nothing is known to me.

The measurements of a specimen from Káfirkot are as follow :—

Entire length of the shell	9 mm.
Length of the dorsal valve	8 „
Entire breadth of the shell (at the hinge-line)	12 „
„ thickness of the shell	3·5 „
Distance of the two valves from each other	2 „
Apical angle of the ventral valve	147°
„ „ „ „ „ without the wings	85°

Locality and geological position.—There are altogether only two specimens of this species known to me, both which were collected by myself at Káfirkot in the middle division of the Productus-limestone.

Remarks.—It is not easy to distinguish the present species from the preceding one, and it was chiefly the great flatness of the valves and the often dichotomous ribs, which led me to distinguish specifically between the two forms. These differences, just pointed out, will most easily be detected in comparing the frontal apical and lateral views of the different specimens figured on Pl. LX. Also the

more considerable length of the hinge-line is a feature which may serve for characterising the present species.

In this latter character, however, it approaches again more closely to *Chon.* (*? Spirifer*) *barusiensis*, Dav., and yet the hinge-line of my *Chon. deplanata* is considerably shorter in comparison to the length of the shell than is the case with Davidson's species. Otherwise, the shell from Kashmir seems to be also more inflated than *Chonetes deplanata*.

13. Chonetes grandicosta, Waagen, n. sp., Pl. LXI., figs. 6, 7.

Among all the species belonging to this group the present is the one which is most extremely developed in all its characters.

The shell is very strongly inflated and enrolled, the sinus very deep and broad, the wings small and pointed, and the whole surface covered by very strong radiating folds.

The ventral valve is most strongly inflated, and exhibits in the longitudinal direction a strong parabolical curve. The apex is pointed, slightly prominent, and extremely bent over, so much so that the very broad area is entirely concealed under the upper sharp areal margins, while the area forms an angle of about 90° with the plane of the valve. The deltidial fissure is very large. On the sharp upper margins of the area, the points of insertion of three (perhaps four) spines on each side of the apex can be observed. The very deep and broad sinus commences immediately at the apex, and occupies in its breadth nearly half of the entire surface of the valve: it is limited on both sides by extremely prominent rounded folds, which occupy the remaining space of the valve with the exception of the small pointed wings. Besides these general features of sculpture; the whole valve is covered by a radial plication, which is rather fine within the sinus and extremely strong on the elevated folds that border it on both sides. Within the sinus there are between five or six ribs, and on the elevated folds there are again five very strong and elevated ribs on each side. The wings are smooth and devoid of a radial plication. This radial sculpture is crossed from distance to distance by fine slightly imbricating striæ of growth. Between these, if the surface of the shell is very well preserved, a fine scaly structure can be observed. If, however, the shell is only very slightly weather-worn, large punctures appear, which are arranged irregularly in radial rows.

The dorsal valve of this species is not known to me.

Also nothing could be observed of the interior characters of this species.

The measurements of two specimens are as follow:—

	I.	II.
Entire length of the shell	11 mm.	10·5 mm.
Breadth of the area	?	2 „
Entire breadth of the shell at the hinge-line	14 „	14 „
Breadth of the deltidial fissure	?	2 „
Entire thickness of the shell	8 „	6 „
Apical angle of the ventral valve, without the wings	74°	81°

Locality and geological position.—There are only three specimens of this species known to me, all three of which were collected by myself in the cephalopoda bed of the upper Productus-limestone at Jabi.

Remarks.—This species is very peculiar in all its characters, and it can be very easily recognised. Though it is more or less nearly related to all the species that have been described above of the same group of forms, yet it is very easily distinguishable, and the differences are so obvious that it seems hardly necessary to point them out in detail.

14. Chonetes æquicosta, Waagen, n. sp., Pl. LX., fig. 7.

This shell is considerably smaller than all those previously described of the same group, except *Spir. barusiensis*, Dav., which is nearly of the same size.

It is about as broad as it is long, of a slightly trapezoidal outline, well vaulted, with a narrow sinus and a very regular fine radial plication.

The ventral valve is rather strongly inflated, but its curve is not quite regular, being stronger in the apical than in the frontal region. The apex is pointed, slightly prominent, and very strongly incurved. The area is inclined under the apex and entirly concealed; it is also covered up by rocky matter in the two specimens at my disposal. The sharp margins which limit the area above are, however, well exposed, and seem to bear traces of two to three spines on each side of the apex. The sinus begins at the very extremity of the apex, but is narrow and not very deep: it is limited on both sides by low, broad, rounded folds, which are followed again by the small, flattened and pointed wings. The whole valve is covered by a very equal radial plication which is not quite correctly represented in the figures on Pl. LX. There are four to five folds within the sinus, which are of very equal size; then follow two slightly stronger ones on the top of the lateral folds; and then again about eight somewhat finer ones, which still cover part of the wings. That part of the wing, however, immediately adjoining the areal margin is smooth.

The minute sculpture of the valve is smooth, not scaly; and the larger punctures seem to be scarce, but are not very distinct.

Neither the dorsal valve nor the interior characters of the species are known to me.

The measurements of a specimen from Jabi are as follow:—

Entire length of the shell	7	mm.
„ breadth of the shell at the hinge line	9	„
„ thickness of the shell	3	„
Apical angle without the wings	100°	

Locality and geological position.—There are altogether only two specimens known to me both of which were collected by myself at Jabi in the cephalopoda-bed of the upper Productus-limestone.

Remarks.—On a first glance, it seems to be nearly obvious that the present species is only the young of the preceding one, and that it is quite superfluous to

make a new name for the present form. For a long time I held this opinion, and it was only after a closer comparison that I found it not practicable to unite the two forms. *Chon. æquicosta* has a differently curved ventral valve, the apex is more strongly incurved, and the remainder more flattened, the sinus is narrower and less deep and the radial plication more equal. Also the minute sculpture of the shell is different. These differences would not exist if the present shell were only the young of *Chon. grandicosta*, and thus I came to the conclusion that we had to deal with a different and smaller species.

The present species very nearly agrees in size with *Spir. barusiensis*, Dav., but the proportions are quite different. Whilst *Spir. barusiensis* is just twice as broad as it is long, in *Chon. æquicosta* the length and breadth are nearly identical.

Of other species none can be compared more closely to the present one.

Genus: STROPHALOSIA, King.

The characters of this genus are very easily recognisable, particularly if one has to deal with quite typical species. The well developed, very distinct area in both valves, the always deformed apex of the ventral valve, produced by the circumstance that it has been fixed to foreign bodies, and the consequently always more or less irregular shape of the whole shell, are the very striking characters which make a recognition of the shells belonging to the genus very easy. Internally, the presence of cardinal teeth is very important, but not so striking, as these teeth can only be rarely observed. Of equal importance are the absence of dentritic muscular impressions and the circumstance that the interior pair of adductor-scars in the dorsal valve is always strongly raised.

These characters are all developed in a typical manner in the species of *Strophalosia* that occur in the permian formation, but as soon as we turn to forms from other beds, it seems difficult to re-detect all these characters. King quotes two species from the devonian and one from the mountain-limestone, which he considers to belong to the genus *Strophalosia*. One of the devonian species, *Strophalosia subaculeata*, Murch., has in the meantime by Hall been made the type of his genus *Productella*, and it is doubtful if the other should not be considered as belonging to the same genus. The carboniferous *Strophalosia buchiana*, Kon., sp., seems to possess a very small area as it has been entirely overlooked by Mons. de Koninck, who figures the shell without a trace of it. Thus this species also seems at least not to be a typical form of *Strophalosia*, and so there remains only the permian species having the striking external appearance of the genus. To these has been added a truly carboniferous species, *Strophalosia cornelliana*, by Derby, who detected this shell in the upper carboniferous beds of the River Tapajos in Brazil.

In the permian beds of Europe about six species of *Strophalosia* have been detected up to the present, which all seem to belong to approximately the same group of forms, of which *Strophalosia goldfussi*, Munst. (*emend.* Geinitz), is the geologically oldest and may be considered as the typical species. To this group belong

two shells occurring in the Salt-range, which are identical with European species: *Strophalosia excavata*, Gein., from the upper region of the middle Productus-limestone, and *Strophalosia horrescens*, Vern., from the lower region of the same division.

One species of *Strophalosia* has been already described by Davidson from the Salt-range under the name of *St. morrisiana*, King. *Var.* There can be no doubt at all that this shell is extremely similar to King's species, and if only two specimens are available, as was the case with Mr. Davidson's materials, it appears most natural to unite this shell with *St. morrisiana*. Nevertheless, after having studied extensive materials of this species most carefully, I have come to the conclusion that the Indian shells belong to a group of forms entirely different from *St. morrisiana*, which most probably replaces the *St. morrisiana* in southern countries, and of which *St. cornelliana*, Derby, must be considered as the prototype. This group is represented in the Salt-range by two species: *St. varispina*, W., in the middle, and *St. indica*, W., in the cephalopoda-bed of the upper division of the Productus-limestone.

A third group of forms is entirely restricted to the lower Productus-limestone. As the prototype of this group, most likely the *Strophalosia gerardi*, King, from Spiti can be considered. The group is represented by three species in the Salt-range: *Strophalosia plicosa*, W., *Strophalosia nodosa*, W., and *Strophalosia tenuispina*, W.

Lastly, there still remains a species which is again very nearly related to a European form: *Strophalosia leplayi*, Gein. (*non Productus leplayi*, Vern). The Indian shell cannot be directly identified with that species, but its near relation to the form from the "Weissliegenden" of Germany is all the same of great interest. This shell will bear the name of *Strophalosia costata*, W.

Thus we have altogether eight species of *Strophalosia* in the Salt-range, a number that exceeds by two the number of species occurring in the permian beds of Europe. This fact is, as it appears to me, of high geological importance, and gives to the Brachiopod-fauna of the Salt-range a very young geological or newer palæozoic aspect.

These eight species can be grouped, as has been indicated above, in the following manner:—

a.—Group of STROPHALOSIA GOLDFUSSI, Münst.

1.—*Strophalosia excavata*, Geinitz.
2.— „ *horrescens*, Vern.

b.—Group of STROPHALOSIA CORNELLIANA, Derby.

3.—*Strophalosia varispina*, Waagen.
4.— „ *indica*, Waagen.

c.—Group of STROPHALOSIA GERARDI, King.

5.—*Strophalosia plicosa*, Waagen.
6.— „ *nodosa*, Waagen.
7.— „ *tennispina*, Waagen.

d.—Group of Strophalosia leplayi, Gein.

δ.—*Strophalosia costata*, Waagen.

a.—Group of *STROPHALOSIA GOLDFUSSI*, Münst.

1. Strophalosia excavata, Geinitz, Pl. LXV, fig. 5.

1842. *Orthis excavata*, Geinitz: Leonh. and Bronn's Jahrb., p. 578, Pl. X, figs. 12—13.
1848. *Orthothrix excavata*, Geinitz: Deutsch. Zechst., p. 14, Pl. V, figs. 35—40; Pl. VI, figs. 20—21.
1850. *Strophalosia goldfussi* (Münst.); *Strophalosia excavata* (Gein.); *Strophalosia parva* (King), King: Monogr. Perm. Foss., p. 96, 98, 102, Pl. XI, figs. 19, 20; Pl. XII, figs. 1—17, 33.
1857. *Strophalosia goldfussi* (Münst.), Davidson: Monogr. Brit. Perm. Brach., p. 39, Pl. III, figs. 1—18.
1861. *Strophalosia excavata*, Geinitz: Dyas, Vol. I, p. 93, Pl. XVII, figs. 1—19.

The materials of this species are very small, but the specimen is so characteristic that I think the determination can be made with sufficient accuracy.

The specimen which serves for description is of rather small size, broader than it is long, and distinguishable from all the other *Strophalosia* occurring in the Salt-range by the presence of a broad sinus in the middle of the ventral valve not far from the front.

The ventral valve is moderately inflated, of a broadly triangular outline, with a curve which is in the longitudinal direction strongest in the apical region. Transversely the valve appears somewhat flattened in the middle, whilst the sides bend strongly down. The hinge-line is short, much shorter than the greatest breadth of the shell. The area appears to be small but is covered with rocky matter. The apex is pointed, bent over, and flattened on the top, showing the place where the shell has been fixed to a foreign body during its youth. The sinus developed on this valve commences only at a certain distance from the apex about half way to the front. It is shallow but rather broad; and in this respect, as well as in many other characters, the Indian specimen resembles most that figured by Geinitz, Dyas, Pl. XVII, fig. 12. The whole valve is covered with little spines, which do not appear quite numerous enough on our figure, Pl. LXV., fig. 5, and which are arranged irregularly in quincunx: they are slightly finer and more numerous towards the margins than in the middle of the valve. Between these spines concentric striæ of growth can be observed.

The interior of the ventral valve as well as the dorsal valve are not known to me.

The measurements of the specimen are as follow:—

Entire length of the shell	14 mm.
„ breadth of the shell	16 „
Length of the hinge-line	8·5 „
Entire thickness of the shell	8 „
Apical angle of the ventral valve	108°

Locality and geological position.—The only specimen of this species that exists in the Salt-range collection was collected by myself in the section near Khura, in the top-beds of the middle division of the Productus-limestone.

Remarks.—The specimen that has served for description cannot be determined, I think, otherwise than as *Strophalosia excavata*. It is a specimen which

holds about the middle place between the typical form and the Var. *lewisiana*, Kon. The triangular outline agrees with the typical form, but the small area and the character of the spination is rather more similar to *St. lewisiana*. On the whole, I think, I cannot be very wrong if I quote the specimen under the name of *Strophalosia excavata*, Gein.

2. Strophalosia horrescens, Vern., Pl. LXXV., fig. 6.

1842. *Productus calvus* (Sow.), Kutorga: Verhandl. der Kais. Russ. Min. Ges. zu St. Petersburg, p. 17, Pl. V, fig. 1.
1842. *Productus horrescens*, Murch. Vern. Kayserl.: On the Geol. Struct. of Rruss. and the Ural, p. 15.
1844. *Productus areatus*, Kutorga: Verhandl. Kais. Russ. Min. Ges. St. Petersburg, p. 97., Pl. X, fig. 5.
1845. *Productus horrescens*, Vern.: Rrussia and the Ural Mountains, Vol. II, p. 280, Pl. XVIII, fig. 1.
1846. *Strophalosia horrescens* (Vern.), King: Ann. & Mag. Nat. Hist. Vol. XVIII, p. 28.
1847. *Productus horrescens* (Vern.), Koninck: Monogr. des genres Prod. et Chon., p. 153, Pl. XV, fig. 6.
1861. *Strophalosia horrescens* (Vern.), Geinitz: Dyas, Vol. I., p. 94, Pl. XVII, fig. 30.
1868. *Strophalosia horrescens* (Vern.), var. *pyramidalis* et var. *prismatica*, Golovkinsky: The Permian Formation in the centre of the Kama-Wolgaic Basin: Materials towards the Geology of Rrussia, Vol. I, p. 361, Pl. II, figs. 13—17.

Though three specimens of this species are known to me, yet none of them attains the size of those that have been figured by Mons. de Verneuil; otherwise, they are absolutely identical.

The general outline is more or less squarish, though the length of the hinge-line is very variable. The lateral margins of the shell always unite with the hinge-line at a sharp angle. The median part of the ventral valve is depressed, forming a broad but very shallow sinus, and the apex is truncated by the place of attachment of the valve to foreign bodies. The whole valve is covered with irregularly arranged spines.

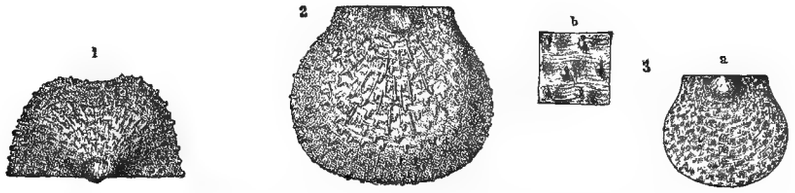


Fig. 18. Strophalosia horrescens, Vern. Three specimens from the lowest beds of the middle-Productus-limestone of Swás: 1. Apical view of the ventral valve, to show the place of attachment; 2. Dorsal valve, impression of the rock; 3. dorsal valve, outer side, (a) natural size, (b) portion of the shell enlarged.

The ventral valve is rather strongly inflated, and its curve is about equally strong in both directions. In the longitudinal direction the valve is most strongly elevated not far from the front, sloping thence slowly towards the apex and rather rapidly towards the frontal margin. Transversely, the valve appears highly elevated and flattened or slightly excavated in the middle, and the lateral parts descend most rapidly to the lateral margins. The apex is bent over and truncated in an irregular manner. The area is covered up by rocky matter and cannot be cleaned on account of the extreme hardness of the rock, but to all appearance it cannot have been very broad. The hinge-line is, in the specimens at my disposal, always shorter than the greatest breadth of the shell. The median sinus does not

commence immediately at the apex but only at a certain distance from it: it is very shallow, and appears as a flattening rather than as an excavation of the shell; it occupies in its breadth the whole median part of the valve, and is limited on both sides by a kind of prominent, nearly angular folds. The lateral parts of the shell descend very steeply to the lateral margins, only in the vicinity of the hinge-line they are a little flattened forming a kind of small wings. The whole valve is covered by very irregularly arranged little spines, between which yet thinner spines can be observed very long and firmly pressed down towards the valve, by which circumstance they have been preserved. These thinner spines between the larger ones have, as far as I am aware, not yet been observed in Russian specimens of this species, but it seems to me that their occurrence entirely depends upon the mode of preservation. The Indian specimens are contained in an extremely hard limestone, and have apparently undergone a very strong pressure, by which these slender spines, which originally rested for their whole extent on the shell surface, have been pressed into the shell substance and have thus been preserved. In another kind of rock every trace of these spines would have been destroyed. Thus I think these are not of very great importance for the determination of the species. Fine concentric striæ of growth are present, but they are not very conspicuous.

The dorsal valve is entirely flat in the visceral portion, whilst the margins suddenly bend up so as to let the whole valve appear more or less concave. The hinge-line is straight, of variable length, and forms always angular wings with the lateral margins of the valve. The area is quite linear. The apex is pointed and slightly prominent, owing to the apical region being a little vaulted corresponding to the truncation of the beak of the other valve. The whole valve is covered with little shallow grooves, corresponding to the spines of the ventral valve. Between these grooves little prominent spines are irregularly disseminated. Some of these spines are also pressed into the shell substance as on the other valve.

The substance of both valves is very thin, and the inner side is just the reverse of the outer one. Though the inside of both valves is well observable on the specimens at my disposal, yet the muscular impressions, as well as the brachial ridges, are so faintly developed that it is impossible to distinguish anything.

The measurements of a ventral valve from Swás are as follow:—

Entire length of the shell	25	mm.
„ breadth of the shell	23	„
Length of the hinge-line	18	„
Entire thickness of the shell	14	„
Apical angle of the ventral valve	93°	

An isolated dorsal valve from the same locality is of somewhat larger dimensions, and indicates a considerably larger individual.

Locality and geological position.—There are altogether three specimens of this species known to me, which all three come from one and the same piece of rock. The specimens consist of two dorsal and one ventral valve, obtained from the same slab of rusty-coloured hard limestone which furnished also many specimens

of *Chonetes strophomenoides*, W., and *Chon. compressa*, W. It has been stated above that this piece of rock came from Swás out of the lower region of the middle Productus-limestone.

Remarks.—The form, which I have described here under the name of *Stroph. horrescens*, seemed to me not distinguishable from the typical form described by Mons. de Verneuil from the permian beds of Russia; and the similarity of the Indian specimens to the Russian seems to me so great, that the entire description as given by Verneuil, word for word, might be applied to them. The most striking character, which is scarcely ever absent in the true *Strophalosiæ*, is the place of attachment on the apex of the ventral valve. Among all the *Strophalosiæ*, occurring in European permian beds, as well as in those that have been found in the Salt-range, this point of attachment is never entirely absent, though it is sometimes rather small, as for instance in *Stroph. excavata*, etc.; and it is this point of attachment which enables us to distinguish between *Strophalosia* and *Productus* in cases in which the existence of cardinal teeth in the ventral valve is not known. The presence of a small area in the ventral valve is utterly unfit for such a distinction, as it is well known that most species of *Productus* might produce a small area in the ventral valve under certain circumstances. This, it seems to me, must be taken into consideration in judging of the figures given by Abich in his "Geologische Forschungen in den Kaukasischen Ländern," Vol. I, Pl. V, figs. 2 and 3, to which have been applied the names of *Productus humboldti*, Orb., and *Prod. scabriculus*, Mart., respectively by the author, but which have been considered to represent *Stroph. horrescens*, by Val. von Möller, on account of the occurrence on one of these specimens of an area in the breadth of one millimeter. Among the specimens of the *Productus humboldti* group, which occur in great numbers in the Salt-range, there are many in which such a small area occurs, and which I am absolutely unable to distinguish from the true *Productus humboldti*, Orb., on the one hand and from Abich's figures on the other. The point of attachment as well as the vertical sides by which the shell appears as if laterally compressed (on both which points great stress is laid in Verneuil's characteristic of the *Strophalosia horrescens*) are absolutely absent in Abich's figures, and thus Mr. Abich's determinations seem to be not quite so abortive as they have been represented to be by Mr. Möller. Thus I have also not accepted Abich's figures as representing *Stroph. horrescens*, and have not quoted them in the table of synonyms preceding the species.

c.—Group of *STROPHALOSIA CORNELLIANA*, Derby.

3. Storphalosia rarispina, Waagen, n. sp., Pl. LXV, figs. 6, 7, 8, 9.

1862. *Strophalosia morrisiana* (King), (?) var. Davidson: Quart. Journ. Geol. Soc. London, Vol. XVIII, p. 32, Pl. II, fig. 8.

1863. *Strophalosia morrisiana* (King), (?) var. (Davidson), Koninck: Foss. paléoz. de l'Inde, pag. 39, Pl. XII, fig. 8.

Mr. Davidson, in his cautious and conscientious manner of recording the results of his observations, quoted the present species under the heading of *Stroph. morris-*

iana, King, (?) var., in order to express on the one hand his conviction that the present shell was identical with King's species, but yet to show on the other hand that there existed some slight discrepancies, which might, if more extensive materials were procurable, make his determination somewhat doubtful. Mr. Davidson had only two specimens, from the upper region of the middle Productus-limestone of Musakheyl, at his disposal; but in the Salt-range collection more than a dozen specimens of this species are preserved, and all show, with the greatest constancy, the same discrepancies from *Stroph. morrisiana* which were pointed out by Mr. Davidson; and thus, it seems to me, the Indian specimens cannot be retained in King's species.

The general outline of this species is very variable and very irregular, but it is always somewhat longer than it is wide. The ventral valve is strongly inflated, with a more or less large point of attachment on the beak; the dorsal valve is concave; the former has not very numerous strong spines, the latter has only traces of them.

The ventral valve is strongly vaulted in both directions, but perhaps somewhat more strongly transversely than longitudinally. The curve is, however, not quite equal for its whole extent: in the longitudinal direction it is tolerably so, but transversely considered the shell appears distinctly depressed in the middle, and sometimes even a shallow sinus is developed. An apex is for the most part non-existant, but its place is occupied by the more or less large place of attachment of the valve. Below this the area extends; it is small, depressed triangular, provided in the middle with a small pseudodeltidium. The hinge-line is short, very considerably shorter than the greatest breadth of the shell. The whole valve is covered by not very numerous spines, which are on an average about 3 millimeters distant from each other. They are of two different kinds: one set is directed forward and more or less firmly pressed down to the surface of the valve; the other is erect, and projects perpendicularly from the surface of the valve. These two sets are quite irregularly mixed together, and show no regularity whatever in their arrangement. Between the spines the shell is smooth, showing only very faint slightly undulating striæ of growth. In some specimens a small number of these striæ of growth is more strongly marked and imbricating.

The dorsal valve is strongly concave, but its external side is rather imperfectly known to me, as no specimen is in my possession showing this valve in a well-preserved state. In the vicinity of the apex, which is slightly prominent, a smooth slightly convex space corresponds to the place of attachment of the other valve. The hinge-line is straight, the area very narrow and interrupted in the middle by the base of the cardinal process. The surface of the whole valve seems to be covered with little grooves, between which very small spines are disseminated.

Of the interior characters of this species only those of the dorsal valve are known to me. The cardinal process is strongly prominent, thick and tripartite at its upper extremity. It is prolonged towards the interior of the valve as a low median septum. At the base of the process, where it unites with the hinge-line on both sides of it, the very distinct and deep dental grooves are situated. The inner

walls of the socket are made up of low, rounded diverging ridges, which originate at the base of the cardinal process. The muscular impressions are peculiar, and I am not quite certain as to how to interpret them. It seems to me that the inner pair of adductors must be considered as bifid, one division being situated above the other. These scars are strongly raised and thickened. The outer pair of adductors, on the contrary, seem to be situated in deep grooves outside and somewhat above the preceding. The brachial ridge is very faint and barely perceptible. It makes a large and widely open curve and joins in the middle the end of the median septum. The whole interior surface of this valve, with the exception of the muscular impressions, is covered by a very fine and very close granulation, which is indistinctly arranged in radial rows.

The measurements of two specimens from near Uchâli are as follow:—

	I.	II.
Entire length of the shell	22 mm.	19 mm.
Length of the dorsal valve	19 „	?
Entire breadth of the shell	20·5 „	18 „
Length of the hinge-line	10 „	9·5 „
Entire thickness of the shell	12 „	10 „

Locality and geological position.—The chief distribution of this species is in the middle division of the Productus-limestone, but in some rare specimens it occurs also in the upper division, up to the Cephalopoda-bed where it is replaced by the next following one. In the middle region of the middle division I collected the species myself on the road between Vurcha and Uchâli (4 specimens) and at Kâfirkot (6 spec.). Mr. Wynne found it in the same geological position at Swâs (1 spec.). In the upper region of the middle division the species has been observed by Mr. Wynne at Chidru (1 spec.); also Mr. Davidson's specimens came probably from the same horizon at Musakheyl. At the very base of the upper division, I collected one specimen west of Khura; and at last, in the middle region of the upper division, I found the species (2 specimens) at Chidru.

Remarks.—This species has been described by Davidson under the name *Strophalosia morrisiana*, King, var., and I must state my reasons for not concurring in this view with Mr. Davidson. Already that author himself drew attention to the fact that the longitudinal striation present in all the well-preserved specimens of *Stroph. morrisiana*, is absent in the Indian shell. It is true that also in *Stroph. morrisiana*, if the surface is not well preserved, the striation is apparently absent; but as little it can be denied, that for the majority of specimens the striation is characteristic. Now, as Mr. Davidson had only two Indian specimens for description, it is not improbable that these two specimens were just not quite well preserved, and so no great stress could be laid on the absence of the striation. But as among my material I have specimens in the very best preservation imaginable, in which also every trace of a striation is absent, this smoothness of the shell must be considered as constituting a specific peculiarity. But also in the spines a difference exists. In *Stroph. morrisiana* the spines are

nearly all directed forward and pressed down, and erect spines occur only in the region of the apex and on the sides. In the Indian specimens, on the contrary, erect spines are mixed all over the shell between the adpressed ones.

In this latter character, as well as in the smoothness of the shell's surface, the Indian shells resemble very closely another species, which has been described by Derby from upper-carboniferous beds of Brazil under the name of *Stroph. cornelliana*. Already Mr. Derby pointed out the close affinity of his species to the Indian form, but I cannot recognise a specific identity, such as Mr. Derby suspected. *Stroph. cornelliana* is more circular in its outline, smaller, and bears by far more numerous spines, the distance between the single spines being in the South American species only one millimeter, whilst this is three millimeters in the Indian shells.

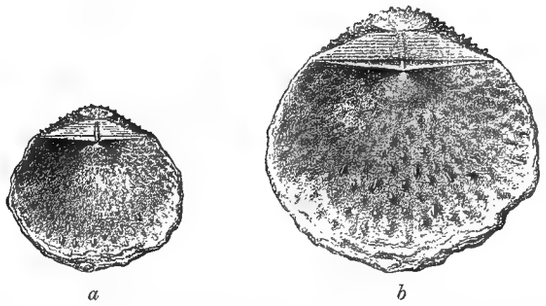
That *Stroph. cornelliana*, as well as our *Stroph. rarispina*, is nearly related to *Stroph. goldfussi*, Münst., has also been already pointed out by Mr. Derby. A specific identity exists, however, in no case. The differences between *Stroph. cornelliana* and *Stroph. goldfussi* have been indicated already by Mr. Derby; between our *Stroph. rarispina* and Count Münster's species these differences consist in the by far more numerous spines, which are all erect in the ventral, and the by far stronger and more numerous spines in the dorsal valve in *Stroph. goldfussi*. *Stroph. cornelliana* is a truly carboniferons species, and it is highly probable that it is the ancestor on the one hand of *Stroph. rarispina*, W., and its allies, and on the other of *Stroph. goldfussi*, Münst., and the other European species. The radially striated *Stroph. morrisiana*, King, belongs to another series of forms.

4. Strophalosia indica, Waagen, n. sp., Pl. LXV., figs. 1—4.

This species is very nearly related to the preceding one, but it is generally broader in its outline and bears a greater number of spines.

The ventral valve is strongly inflated, and its curve is very regular in both directions, a median longitudinal impression never occurring: (the front view, fig. 1 *d.*, Pl. LXV, in which the shell appears somewhat depressed in the middle, is not quite correct). The apex is quite obliterated by the large place of attachment by which it is truncated. Below, there is a tolerably large, smooth, triangular area, which is interrupted in the middle by an extremely narrow and slightly prominent pseudodeltidium. The hinge-line is very considerably shorter than the greatest breadth of the shell. The valve is rather thickly covered with two sets of spines, of which one is directed forward and firmly pressed down to the surface of the shell, whilst the other is erect already from its beginning. The spines are about one and a half to two millimeters distant from each other. In large specimens the margin of the valve becomes coarsely and radially plicated. The depressed spines are situated, for their whole extent, so strictly in the plane of the shell's surface that,

in its advancing growth, the shell very often embodies them in its substance, and thus they are on their lower part covered up by shelly matter.



a *b*

Fig. 19. STROPHALOSIA INDICA, W., n. sp. Dorsal valve of the specimen figured Pl. LXV, fig. 1, entirely cleaned : *a*. natural size ; *b*. enlarged.

The dorsal valve is concave. The apex is slightly prominent and encircled by a smooth space, corresponding to the place of attachment of the other valve. The valve bears a narrow but very distinct area, which is interrupted in the middle by the very narrow base of the cardinal process. The whole valve is covered by a very characteristic minute grooving, between which extremely fine erect spines are irregularly distributed.

The surface of the shell in both valves is perfectly smooth between the spines, and only very faint striæ of growth can be observed, but no radial striation.

Of the interior characters of this species only those of the dorsal valve are known to me. The cardinal process is small and little prominent. It is continued below in a low median septum and is joined laterally at its base by two projecting ridges which form the inner walls of dental sockets. The muscular impressions are very distinct. The inner pair of adductor scars is raised, and each scar is divided by a curved transverse projecting ridge. The whole scar forms a roundish mass. The outer pair of adductors is apparently inserted in deep grooves that encircle the scars of the inner pair above and somewhat outside; each scar is of about semi-lunar shape. The brachial ridges are, in all specimens at my disposal, so faint that they cannot be at all distinguished. Instead of them a smooth shield-like space is observable extending below the scars on both sides of the faint median septum. The meaning of these features I do not know. The whole interior side of the valve is covered by a very finely-granulated radial striation.

In the ventral valve, very strong cardinal teeth are situated on both sides of the deltidial fissure.

The measurements of a full-grown specimen from Jabi are as follow:—

Entire length of the shell	23	mm.
Length of the dorsal valve	20	„
Entire breadth of the shell	24	„
Length of the hinge-line	14	„
Entire thickness of the shell	12	„
Distance of the two valves from each other	7	„

Locality and geological position.—This species is entirely restricted to the Cephalopoda-bed of the upper Productus-limestone, but is extremely common in

this geological position. In this Cephalopoda-bed, chiefly at Jabi, nearly all the shells are covered with young specimens of this species, which are often difficult to distinguish from specimens of *Crania*. The young specimens of this species have also attached themselves to corals, chiefly of a genus allied to *Fistulipora;* and it is interesting to observe how the corals grew all round these specimens and at last enclosed them entirely, whilst the specimens yet lived on in a somewhat parasitical way in the interior of their host. There are several specimens of *Fistulipora*, forming stems of nearly the thickness of a man's fist in which such hollows occur, occupied by small specimens of *Strophalosia*. As the specimens grew larger they detached themselves and got free. This was absolutely necessary for them, because the young specimens are clustered so closely together that it would have been impossible for them to augment in size had they not become detached from their support. Nevertheless, full-grown detached specimens are much rarer than young ones; I brought away about a dozen of them from the Cephalopoda-bed of Jabi, and about the same number from the same bed of Chidru. The size at which the specimens become detached barely ever exceeds 5 millimeters in length.

Remarks.—The present species is very nearly related to the preceding one, and is distinguishable from it chiefly by the circumstance that it bears more numerous spines, which most clearly appears from the fact that the average distance between the spines is 1·5 to 2 millimeters in the present species, while it is 3 in the preceding one. Besides this, the general outline is also broader in comparison to the length, and the strong plication of the margin of the valves is peculiar. The most striking proof, however, of the distinctness of the two species, rests on the interior characters of the dorsal valve in which the muscular impressions in both species are differently placed.

By the more closely set spines, the present species again more nearly approaches the *Stroph. cornelliana*, Derby. Nevertheless a distinction of these two species is very easy. *Stroph. cornelliana* remains always small and its dorsal valve is quite smooth, whilst the Indian shell grows larger and has a dorsal valve bearing a great number of very fine erect spines.

c.—Group of *STROPHALOSIA GERARDI*, King.

5. Strophalosia plicosa, Waagen, n. sp., Pl. LXIII, figs. 2—6.

The whole group to which the present species belongs is characterised by a rather clumsy general shape, a very small often barely perceptible point of attachment in the ventral valve, and a sculpture which consists of rather far distant spines. As in the whole group, so are also these characters well developed in the present species. The peculiarities of the species, however, consist in a very strongly and regularly vaulted ventral valve and broad radial plications, which appear after

the shell has attained a certain size. The species is rather large, but never grows to the size of *Stropn. gerardi.*

The ventral valve is rather variable in its general outline, but in the majority of specimens this outline is nearly circular. The hinge-line is very short and not at all projecting at the ends, so that the general regular curve of the outline is nowhere interrupted. The valve is very strongly inflated, nearly semi-globose, and its curve is rather regular in both directions. The apex is very strongly bent over and pointed; it bears at or near its extremity a small flattened or slightly excavated, irregularly circumscribed space, where the shell had been attached during its youth to foreign bodies. The area is rather small and slightly concave, interrupted in the middle by a small pseudodeltidium. The spines covering the surface of this valve, though apparently rather thick when preserved, are only slightly conspicuous when broken off, as they leave no strong trace on the surface of the shell. They are, as far as can be observed, all directed forward, and are rather distant from each other, leaving a smooth space of 4 millimeters between. At a distance of about 18 to 20 millimeters from the apex, a strong radial plication commences; it is however rather irregular, and has no very distinct relation to the spines on the surface. The margins of the valve are all in one plane.

The dorsal valve is not very strongly concave. The apex is pointed and slightly prominent, surrounded by a very small somewhat vaulted smooth space, which corresponds to the point of attachment of the other valve. The area is distinct but very narrow, nearly linear. The valve is almost quite smooth, only covered by very numerous somewhat lamellar striæ of growth, between which little grooves are situated off and on. Whether projecting spines were present or not, I cannot decide, as the preservation of the dorsal valves of this species is rather indifferent; to all appearances there were none.

The interior characters of this species are not known to me. I have figured Pl. LXIII, fig. 4, the interior side of a dorsal valve, but it is too badly preserved to make out the characters. Also with regard to the ventral valve, I am in a similar position, all the interiors being too badly preserved.

The measurements of a large specimen from the Chittawán are as follow:—

Entire length of the shell	31	mm.
Length of the dorsal valve	26	„
Breadth of the area in the ventral valve	4	„
Entire breadth of the shell	32	„
Length of the hinge-line	16	„
Entire thickness of the shell	19	„
Apical angle of the ventral valve	133°	

The species seems to have attained considerably larger dimensions than those of the above specimen. There is one badly preserved dorsal valve which is about 35 mm. in breadth, indicating a considerably larger individual; and other fragments seem to have come from yet larger specimens.

Locality and geological position.—The present species is entirely restricted to the lowest fossiliferous beds above the lavender-clays, and occurs most numerously in this geological position in the Chittawán near Ghari, where in a hard dark-gray calcareous sandstone, weathering of a rusty colour, thousands of specimens are imbedded; they can however only with difficulty be extracted from the hard rock. At other localities the species is much rarer. It has been collected by myself in absolutely the same geological position, near Amb, in a dark coaly sandstone (2 specimens); and by Mr. Wynne near Dokri (5 spec.) and near Khairabad (1 spec.).

Remarks.—The species here under consideration seems to be very nearly related to *Stroph. gerardi*, King, from beds of unknown age of the Himalaya. I should have liked to identify the present shell with the Himalayan one, but after a lengthened consideration I do not feel justified in doing so. The shell from the Salt-range is always narrower and more semi-globose, the apex much more strongly bent over, the area of the ventral valve smaller, and that of the dorsal one nearly quite absent. Then, the thick radial folds that appear with the progressing size of the specimens, and the but little marked spines on the surface of the ventral valve, all characters by which the Salt-range shell differs from the Himalayan one, forbade the identification: thus I was forced to give a new name to the shell here under consideration.

Of other species none can be compared, more particularly with the present one.

6. Strophalosia nodosa, Waagen, n. sp., Pl. LXIV, figs. 8, 9.

The general outline of this species is not much different from that of the preceding one, but it never attains the same size and generally bears a larger point of attachment in the ventral valve. The chief difference, and at the same time the most striking character of the present species, consists in the sculpture, which is composed of spines of very different size, very thin ones and very thick ones, which are all very irregularly disseminated over the surface of the ventral valve.

The ventral valve is very strongly inflated, nearly semi-globose, with a tolerably equal curve in both directions. The hinge-line is very short, but nevertheless projecting slightly at both ends, so that the ends can be seen in a ventral view of the shell as little projecting corners. The area is tolerably large, concave and interrupted in the middle by a very narrow little-vaulted pseudodeltidium. The apex is prominent, sometimes indistinctly pointed, sometimes truncated, and not much bent over. The most characteristic feature of the valve is its sculpture. It consists altogether of erect spines, which are, however, of very different sizes. One set of them is extremely thin, and leaves barely perceptible points on the surface of the valve when the spines are broken off; the other set is very thick and in case of fracture leaves thick knob-like projections on the valve. The relative number of the two sets is very variable, and sometimes the thin, or again the thick set is the more prevalent. If the former is the case, the thick spines are sometimes only represented by the number of five

or six on the whole surface of the valve. Also, the distribution of the two sets is very irregular, and both kinds are disseminated quite irregularly between each other.

The dorsal valve is not quite well preserved in any of the specimens at my disposal. It is concave, with a slightly prominent apex, round which the valve is a little vaulted according to the point of attachment of the other valve. The area is very distinct and comparatively broad, interrupted in the middle by the small knob-like root of the cardinal process. The whole valve seems to be covered with irregularly distributed little pits, but it cannot be stated whether little spines were disseminated between them or not.

The interior characters of the species are also very imperfectly known to me. It is certain that the ventral valve possessed very narrow but very long and well-developed cardinal teeth, which fitted into very deep dental grooves in the dorsal valve. The muscular impressions are apparently in both valves much in the same way as in other species of *Strophalosia*, but they are rather indistinct in the specimens at my disposal, and the brachial ridge cannot be at all distinguished.

The measurements of two specimens from Amb are as follow :—

	I.		II.	
Entire length of the shell	25	mm.	19	mm.
Length of the dorsal valve	21	„	17	„
Entire breadth of the shell	27	„	19	„
Length of the hinge-line	19	„	11	„
Entire thickness of the shell	13	„	11	„
Distance of the valves from each other	8	„	?	
Apical angle of the ventral valve	117°		118°	

The specimen No. I is the largest known to me of this species.

Locality and geological position.—The present species was detected by me only at a single locality in the Salt-range. This was at Amb, where it occurs rather plentifully in the *Chonetes*-bed of the lower Productus-limestone. I brought away 27 specimens.

Remarks.—In its general outline the present species is very nearly related to the preceding *Strophalosia plicosa*, but the hinge-line is a little longer and slightly projecting at both ends, and the sculpture is quite different. The knob-like insertions of the thick spines, which are erect from their roots, are very different from the insertions of the spines in *Strophalosia plicosa* which are thin and directed forward, though afterwards these spines also become erect. It needs only a look at the figures to make these differences apparent.

There exists, moreover, a similarity to another species, and this is the true *Strophalosia goldfussi*, Münst., as described by Geinitz. In general habitus both species seem to be very similar, chiefly by the circumstance that in both the spines are erect from their roots, but in *Strophalosia goldfussi* the spines are much more numerous than in the Indian shell, and the dorsal valve bears also strong spines, which is decidedly not the case in *Strophalosia nodosa*.

7. Strophalosia tenuispina, Waagen, n. sp., Pl. LXIV, figs. 2—7.

The general outline of this species is circular to transversely oval. The ventral valve is not much inflated and is covered by very fine spines, which are directed forward. The interior of the dorsal valve is very peculiar.

The ventral valve is nearly flat to slightly inflated, and its curve is tolerably regular in both directions; only longitudinally the curve is perhaps somewhat flatter in the apical than in the frontal region. The point of attachment on the apex of this valve is very small; and the truncation of the apex, which is caused by it, is only preceptible on a very close examination. The apex is slightly bent over but not prominent, and thus the area appears quite flat, not concave. This latter is not very large and bears in the middle a narrow pseudodeltidium. The hinge-line is comparatively long and projecting at both ends. The surface sculpture of the valve is characteristic for the species. I have figured different states of preservation on Pl. LXIV. In the specimen represented in fig. 3, the spines are entirely broken off on the greater portion of the shell, so that nothing but the roots remain. In figs. 2, 6, and 7, on the contrary, small pieces of the spines still adhere to the roots, and thus the whole aspect of the shell is changed. The spines are thin, directed forward, firmly pressed down to the surface of the valve and arranged approximately in concentric rows, which are marked by well-developed imbricating striæ of growth. There are no erect spines disseminated between the adpressed ones.

In the dorsal valve, I have not succeeded in cleaning the outer side from the adhering rock matter; it seems, however, that this valve was provided with spines very similar to those of the other valve. The area of this valve is small, nearly linear.

Of the interior characters of this species, only those of the dorsal valve are known to me. The cardinal process is rather small, and bears at its base on both sides the very deep slit-like dental grooves, which approach each other very nearly, leaving only a thin shelly mass between them. The cardinal process is prolonged into a distinct median septum, which extends for about half the length of the dorsal valve. The two pairs of adductor impressions are very clearly distinguishable. The scars are somewhat lozenge-shaped, the inner pair larger and slightly raised, the outer pair shorter and excavated. The brachial ridges are not distinguishable. In their place a shelly callosity of a somewhat bilobed outline exists. The whole internal surface of the valve, with the sole exception of the muscular impressions, is covered with a finely granulated radial striation.

The measurements of two full-grown specimens from Amb are as follow:—

	I.	II.
Entire length of the shell	23 mm.	23 mm.
„ breadth of the shell	26 „	27 „
Length of the hinge-line	? 14 „	15 „
Entire thickness of the shell	10 „	7 „
Apical angle of the ventral valve	123°	141°

Locality and geological position.—Like the preceding species this one also is restricted to a single bed and locality in the Salt-range. I collected the species at Amb in the so-called *Chonetes*-bed, associated with *Chonetes ambiensis*, W., *Strophalosia nodosa*, W., and several other species. The present species is, however, considerably rarer than those two forms; I brought away only ten specimens.

Remarks.—The present species seems to be more or less nearly related to several of the forms previously described, and chiefly there exists a rather close similarity between the present shell and *Stroph. plicosa*. Nevertheless, I think the two shells can well be distinguished, as *Stroph. tenuispina* has a much less strongly inflated ventral valve and finer and much less numerous spines. The dorsal valve, so far as it can be observed, is entirely different, as it possesses apparently comparatively strong spines, while that of *Stroph. plicosa* shows only fine lamellar striæ of growth.

A closer comparison of the present species with the forms of the group of *Stroph. goldfussi* or of the group of *Stroph. cornelliana* seems hardly necessary, as the shell here under consideration seems to be sufficiently distinct to allow of its being recognised without indication of the distinguishing characters.

d.—Group of *STROPHALOSIA LEPLAYI*, Geinitz.

8. Strophalosia costata, Waagen, n. sp., Pl. LXIII, figs. 7, 8; Pl. LXIV, fig. 1.

This neat little species is of a transversely oval or somwhat rectangular outline, with a strongly inflated ventral valve and a sharply costate surface. On the costæ moderately projecting spines are distributed.

The ventral valve is strongly vaulted, with a distinct longitudinal sinus in the middle. Its curve is rather regular and equal in both directions. The apex is mostly truncated by the place of attachment of the valve; but in some cases, when the shell has been fixed during its youth to a concave body, the apex is complete, though somewhat crumpled, and then it is pointed and strongly bent over. The hinge-line is always shorter than the greatest breadth of the shell. The area is concave and narrow, and the deltidial fissure seems to be small, but it cannot be distinctly seen in any of the specimens, as just this part is always covered up by very hard rock matter. The whole surface of the valve is covered by very strong radiating ribs, which sometimes bifurcate and are ornamented at intervals with strong spines. In specimens with a small point of attachment, and which in consequence have a longer hinge-line, a greater number of spines is clustered together towards both ends of this line. In other specimens, with a large point of attachment and a shorter hinge-line, these spines are very much reduced in size and number, or they are even entirely absent. But otherwise, in all specimens the radiating ribs are strongly nodose and ornamented with spines, which are distributed quite irregularly over the whole valve.

The dorsal valve is flatly concave, with a but slightly developed median fold. The apex is pointed and slightly prominent, surrounded by a convex part of the shell corresponding to the place of attachment of the other valve. A narrow but distinct area is present in this valve. The surface of the valve, with the exception of the convex part round the apex, is covered with low radiating folds, between which shallow pits correspond to the places where on the other valve spines are situated. These pits sometimes become the leading feature of the valve as in the specimen of which an enlarged figure is given, Pl. LXIV, fig. 1c. This valve is absolutely devoid of any trace of spines. Faint concentric striæ of growth can be observed.

The internal characters of this species are entirely unknown to me.

The measurements of two specimens, No. I from the *Chonetes*-bed, and No. II from the lowest fossiliferous bed above the lavender-clay of Amb, are as follow:—

	I.	II.
Entire length of the shell	14 mm.	13 mm.
Length of the dorsal valve	12 „	11 „
Entire breadth of the shell	20 „	14·5 „
Length of the hinge-line	16 „	10 „
Entire thickness of the shell	10 „	7 „
Distance of the two valves from each other	? „	5 „
Apical angle of the ventral valve	85°	?

Locality and geological position.—There are altogether only three specimens of this species known to me, all three of which were collected by myself; one of them in the *Chonetes*-bed and the two others in the lowest fossiliferous beds above the lavender-clay; that is to say, all three in the lower division of the Productus-limestone, at Amb.

Remarks.—The present species seems to all appearances very nearly related to *Stroph. leplayi*, Gein., of the European permian formation. Some confusion seems, however, to prevail about this European species, and it is necessary to state first what I include under the name. From permian beds of Russia a shell had been described by Count de Verneuil under the name of *Productus leplayi*, which afterwards was identified by Geinitz with a shell from the "Weissliegenden" of Tieochitz near Gera, and which was manifestly a *Strophalosia;* so that Geinitz in his text of the "Dyas" changed the name of *Productus leplayi* into *Strophalosia leplayi*. But afterwards he himself seems to have become uncertain of the identification, and on the explanation of the plates he quotes two species one at the side of the other: *Productus leplayi*, Vern., and *Strophalosia leplayi*, Gein. This latter proceeding seems to me the correct one. *Strophalosia leplayi* differs, according to my opinion, from *Productus leplayi* by its much smaller size, the fine radial striation, the shorter hinge-line, and the attached ventral valve. That the ventral valve of *Strophalosia leplayi* was in reality attached appears beyond all doubt from Geinitz's figures and description of the species: in these he mentions and draws a smooth space round the apex of the dorsal valve, a character which would not be present if the ventral valve was quite free as this smooth space of the dorsal

valve just corresponds to the place of attachment of the ventral one. It needs only a look at Geinitz's figures (chiefly fig. 25, Pl. XIX of the Dyas) to become convinced of the circumstances. It is this *Strophalosia leplayi* to which I think that the Indian *Strophalosia costata* is most nearly related. Some palæontologists might perhaps be inclined to consider the two as identical, but I think one should not go so far in the identification. *Strophalosia costata* is slightly larger, has got coarser radial ribs, and bears more spines on them; and thus I should rather advocate its specific separation from the European permian shell. Nevertheless, the very near relation of the two forms remains, and it is probable that the *Strophalosia costata* must be considered as a geographical variation or representative form of *Strophalosia leplayi*.

Of other species there is none known to me, to which the shell here under consideration could be more particularly compared.

Genus: CHONETELLA, Waagen, n. gen.

There is only a single species for which I have to introduce this new genus, but it is very common in the Salt-range, and its external and internal characters are so peculiar, that I cannot place it in any of the genera which have been distinguished up to the present.

On the first glance everybody would take this shell to be a *Productus*, as its external appearance is entirely *Productus*-like. But on a closer examination one finds that the ventral valve bears a narrow but distinct area, which is interrupted in the middle by a small deltidial fissure; and it is ornamented along its upper margins on both sides of the apex with thin spines, just as they occur in the genus *Chonetes*. Also in most specimens a linear area exists in the dorsal valve. The chief distinguishing characters of the genus are however to be found in its internal peculiarities.

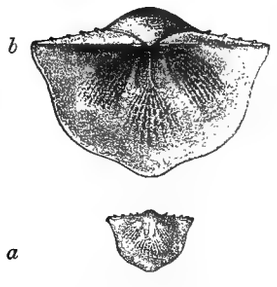


Fig. 20. CHONETELLA NASUTA, W., n. gen. et sp. Specimen from the Cephalopoda-bed of Amb: *a*. internal cast of the ventral valve, natural size; *b*. gutta-percha impression of the same, enlarged.

The ventral valve bears on both sides of the deltidial fissure rudimentary cardinal teeth. The muscular impressions are deep and large. The adductors have left somewhat reniform elongated impressions on both sides of the middle line, not far from the apex; they are however not dendritic; the divaricator

impressions are larger and situated somewhat outside and lower down than the preceding. They are of a somewhat rectangular shape and longitudinally striated as in *Productus*.

In the dorsal valve a very small trilobed cardinal process exists, at the base of which on both sides are situated very indistinct shallow dental grooves. The cardinal process is continued as a thin, low median septum down to about half way in the length of the valve. The muscular impressions are very distinct. All four are somewhat lozenge-shaped, and the inner pair is somewhat larger than the outer one, and at the same time somewhat lower down in its position. None of the impressions is dendritic. The brachial ridges are very distinctly visible in all the specimens at my disposal, but their origin remains always doubtful. It would appear as if they originated at the lower end of the outer pair of adductor impressions, but I cannot be quite certain of the circumstance. So much is however certain, that they do not distinctly proceed from between the two pairs of adductor impressions as is the case in other *Productidæ*. The form of these sharply prominent ridges is at the same time very peculiar; they first descend in a broad curve, about parallel to the margin of the valve, and then suddenly bend round in a narrow curve as if they would form a spiral, and terminate suddenly as if cut off. I have figured these specimens in order to show that these characters are constant. The whole interior surface of the valve is largely papillate, except the space within the brachial ridges.

From this description of the characters, it appears that the shells here under consideration are truly transitional forms between *Chonetes* and *Productus*. They can, however, not be united with *Chonetes* on account of the scarcely developed area and hinge teeth, nor with *Productus* on account of the little spines with which the upper margins of the area are ornamented. Charact in which the present genus deviated from all the other genera of the *Productidæ* are exhibited in the brachial ridges of the dorsal valve.

If we take exception to the two above-mentioned genera, the form here under consideration can only as yet be compared to those shells which have received the names of *Prod. llangollensis*, Dav., and *Prod. comoides*, Sou., and which constitute to my view the genus *Daviesiella*, Waagen. From these shells, the present form is distinguished by the absence of a second pair of adductor impressions in the ventral valve and by differently disposed brachial ridges.

The genus is represented in the Salt-range by a single species, which will receive the name of *Chon. nasuta*, W. I know of no other shell in any country which with any probability could be attributed to the present genus.

I.—Chonetella nasuta, Waagen, n. gen. et sp, Pl. LXXXI, figs. 3—8.

For a long time I considered this little shell as a *Productus*, and only after a very close and very careful investigation was I convinced that I had in it to deal with a shell of different generic characters.

The general outline of the shell is entirely like that of a *Productus*. The ventral valve is very strongly inflated in the middle with little wings on both sides. It bears a fine radial plication, and in the middle of the frontal margin a large nose-shaped process. The dorsal valve is strongly concave. The distinct area which exists in both valves is almost entirely concealed, as it is so strongly overhanging that its upper sharp margins appear as if they were the hinge margin.

The ventral valve is very strongly inflated, its curve being very regular in the longitudinal as well as in the transverse direction, the lateral wings being but little flattened and slightly projecting. The apex is slightly prominent, pointed and very strongly bent over. The area is tolerably broad, a little concave and quite concealed below the apex. It is cut open in the middle by a rather narrow deltidial fissure. The upper very sharp margins of the area are ornamented with four to five spines on each side of the apex, which are directed towards the end of the hinge-line. Not far from the apex, a generally very shallow sinus commences and about half way to the front suddenly changes into a high and prominent fold, which is prolonged in the front into a narrow, long, nose-shaped process. The whole valve is covered with a rather faint radial plication, which is sometimes well developed, sometimes barely at all preceptible. The single folds are narrow, rounded on the top, and often dichotomous towards the frontal margin. As a very great exception (in two cases among the 30 specimens at my disposal), one or the other of these ribs bears a spine somewhere in its curve. The number of the radial folds is between twenty and thirty.

The dorsal valve is concave, and is in every respect the reverse of the other valve. It bears a prominent median fold to about half way from the apex, when this suddenly changes into a deep rather narrow furrow, which is prolonged into the nose-shaped process. The lateral portions of the valve bear a more or less distinct radial plication. Along the hinge-line, a narrow but distinct area extends, which is interrupted in the middle by the little prominent cardinal process.

The interior characters of the species are such as have been described in the characteristic of the genus.

The substance of the shell is of a silky lustre as in *Productus*, but I cannot detect in any of the specimens, when the outermost shell layer is destroyed, the fine punctures, which are so very characteristic for the shell of *Productus*.

The measurements of two specimens, No. I, a strongly inflated variety with small wings, from the base of the upper Productus-limestone of Khura, and No. II, a less strongly inflated variety with large wings, from the Cephalopada-bed of Chidru, are as follow :—

	I.	II.
Entire length of the shell	13 mm.	9 mm.
Length of the dorsal valve	9 „	7 „
Entire breadth of the shell (at the hinge-line)	13 „	14 „
„ thickness of the shell	7 „	5 „
Apical angle of the ventral valve	122°	130°

The distance of the two valves from each other is 3mm, in a specimen of 10mm. in length. The specimen No. 1 is the largest one known to me.

Locality and geological position.—This is a rather common species in the Salt-range, and it extends through the whole middle and upper divisions of the Productus-limestone. It is, however, most numerous in the lower beds of the upper division.

The geologically oldest specimen that is known up to the present was collected by myself at Katta in the lower beds of the middle Productus-limestone (bed No. 12 of my note-book) (1 spec.). In somewhat higher beds of the middle division, I found the species in the section near Khura (1 spec.), and in the middle region of the middle division, on the road between Vurcha and Ucháli (4 spec.), and at Káfirkot (4 spec.). The top beds of the middle division have furnished specimens at Khura (1 spec.) and at Kálabágh (1 spec).

In the lower region of the upper division the species was collected by myself west of Khura (18 spec.), and at Katwáhi (4 spec.). Lastly, in the Cephalopoda-bed of the upper Productus limestone, the species occurred at Jabi (9 spec.) and at Chidru (4 spec.).

Remarks.—As the present species has in its external appearance entirely the look of *Productus*, it is also among the species of that genus that we must look out for relations to the present form. In fact there is such a shell, and it has been described by Mr. Davidson as an exceptional shape of *Productus longispinus*, Sow. These little shells have been found in carboniferous-shale near Carluke in Lanarkshire, and as I have not got specimens for comparison I must rely entirely on Mr. Davidson's drawings, which are, however, of such a well-known quality that they appear as nearly of the same value as natural specimens. Above all, it appears highly probable that these little shells, though the interior of the dorsal valve is not known, belong to my genus *Chonetella* as in fig. 18 (Pl. XXXV of the Carboniferous Monograph). Mr. Davidson draws a distinct area in the ventral valve. As to specific differences, the shell from the mountain-limestone has apparently no spines along the upper margins of the area of the ventral valve, and on the surface of the ventral valve much more numerous spines seem to be present than in the Indian species, where the occurrence of a spine anywhere on the ventral valve, except along the margins of the area, is a very great exception.

Now these little shells, the Indian as well as the English, ought not, according to my opinion, to be considered as simple varieties of *Productus longispinus*, Sow., as their internal structure is very different. *Productus longispinus*, Sow., and its allies belongs to that group of forms which I shall consider later on in the text under the name of *Marginifera*, and the characters of which group will be duly described in the right place. Of these characters, however, not a trace is to be found in *Chonetella*, and thus these shells appear not only specifically but even generically different from *Productus longispinus*.

Sub-family: *PRODUCTINÆ.*

Genus: AULOSTEGES, Helmersen.

The occurrence of this genus in the palæozoic strata of the Salt-range is of very great interest, so much the more as I am in a position to add to the species already made known by Mr. Davidson, a new one which is very common at certain localities.

The generic characters seem not yet quite definitely fixed, as every new species that becomes known adds something new to our knowledge of these characters, and thus it appears difficult to draw up a generic description.

The general shape of the shells belonging to the genus is flat, with a convex ventral and a flat or concave dorsal valve. The ventral valve, though mostly with a deformed apex, as *Streptorhynchus*, is never attached but always free. It is provided with a more or less large flat area, which bears in the middle a narrow pseudodeltidium, provided, if well preserved, with little spines. Interiorly this valve seems to be generally edentulous; but in the specimen of *Aul. dalhousii*, figured by Davidson, small rudimentary hinge-teeth are drawn and described, so that hinge-teeth seem to have been sometimes developed. In the other species occurring in the Salt-range no hinge-teeth are present. The muscular impressions of the ventral valve connot be observed in any of the Indian specimens.

The dorsal valve has a linear area, a large cardinal process, and dendritic adductor impressions. The brachial ridges reach far down to near the margin of the valve, but are otherwise like those of *Productus*. This seems to be the case in *Aulosteges wangenheimi*, Vern., and *Aulosteges dalhousi*, Dav. The arrangement of the brachial ridges is, however, quite different in *Aulosteges medlicottianus*, W., the second species that occurs in the Salt-range, and perhaps this arrangement could be made use of to distinguish this shell generically; but I should not like to advocate this, as only a single interior side of the dorsal valve of this species is known to me, and it would be desirable to make some further investigations before deciding on this question. The brachial ridges are very short in this species, proceed horizontally from between the muscular impressions, then bend round in a sharp corner, and return with a somewhat parabolical curve to the median septum.

The geological distribution of the genus is chiefly permian, and it has been already remarked by Davidson that the occurrence of a species of *Aulosteges* in the Salt-range might indicate the existence of permian strata there.

In the Salt-range the two species which exist there occur at two different horizons. The species that has been described by Davidson, *Aul. dalhousii*, belongs to the upper region of the middle Productus-limestone of Musakheyl, and the second species, *Aul. medlicottianus*, W., is restricted to the lower Productus-limestone, but it occurs there at different localities and sometimes in great numbers.

The two species are, however, apparently in no connection whatever together.

1. Aulosteges dalhousii, Davidson, Pl. LXIII., fig. 1.

1862. *Aulosteges dalhousii*, Davidson: Quart. Journ. Geol. Soc., Lond., Vol. XVIII., p. 33, pl II., fig. 7.
1863. *Aulosteges dalhousii*, (Dav.) Koninck: Foss. paléoz. de l'Inde, p. 41, pl., XII., fig. 7.

I regret to say that the materials of this species at my disposal are very scanty, only a single-well preserved ventral valve being contained in the Salt-range collection. I must thus, in everything that regards the dorsal valve, copy from Mr. Davidson's description.

The general ontline of the shell is broadly triangular, with a vaulted ventral and a flat or slightly concave dorsal valve. The hinge-line is short, not projecting at both ends, and the area of the ventral valve very large and reclining.

The ventral valve is not very strongly vaulted, and its curve is very irregular. Longitudinally, the valve is tolerably flat to not very far from the front, then it suddenly bends up to the front line. Transversely, the curve is more regular, but indented in the middle by the broad and deep median sinus, which extends from the front line to about half way up the length of the shell. The apex is prominent, pointed and a little bent over in normal specimens, but very strongly incurved and somewhat swollen in my specimen, a conformation which is evidently caused by malformation. The area is very large and flat, very strongly striated vertically, and with a few inbricating striæ of growth parallel to the hinge line. It is interrupted in the middle by a very narrow deltidial fissure, which is of nearly equal breadth for its whole extent. This fissure is bridged over nearly down to the very hinge-margin by a little vaulted pseudodeltidium, which bears many imbricating striæ of growth and is thickly covered by little spines. At the hinge-margin it leaves only a very small space open for the reception of the apparently very small cardinal process of the dorsal valve. The whole surface of the valve, with the exception of the area, is covered with closely set spines, of which the majority is directed forward, whilst between them are some which are slightly thicker and erect. The spines with a forward direction are mostly pressed down firmly to the surface of the valve.

I do not know the dorsal valve of this species from my own observation. What Mr. Davidson says about this valve is as follows: The dorsal valve is convexo-concave,—that is to say, it is convex up to a little distance from the margin, and then bends up and becomes concave. The area of this valve is narrow and linear. The whole surface seems to have been covered with thin spines. Interiorly the cardinal process is trifid, and there are traces of the small dental sockets at both sides of its base. The cardinal process is continued in a small median septum which extends somewhat in excess of half of the length of the valve. On each side of this septum two elongated oval dendritic inpressions are to be found, which without doubt represent the impressions of the adductor muscles. At their inner extremities commence the reniform impressions (brachial ridges): these are marked by a curved line which, extending to near the margin of the valve and then abruptly bending round, terminates not far from the point whence it had started.

The measurements of the specimen at my disposal are as follow :—

Entire length of the shell	44	mm.
Height of area	10	„
Entire breadth of the shell	48	„
Length of the hinge-line	32	„
Breadth of the pseudodeltidium at the hinge-line	3	„
Entire thickness of the shell	19	„
Apical angle	100°	

Locality and geological position.—There are altogether only two specimens of this species known up to the present. One of them was collected by Mr. Purdon, and has been described by Mr. Davidson, and the other was found by Mr. Theobald, and has served here for the description. Both these specimens come from Musa-kheyl, and were undoubtedly collected there in the upper beds of the middle Productus-limestone.

Remarks.—The present species appears on the whole to be very nearly related to *Aul. wangenheimi*. Vern., from permian beds of Russia. It is entirely of the same type and configuration, and it is highly probable that the two are either in a developmental connection, or that they are forms of the same geological age, representing each other in different geographical regions.

The difference that exists between the two forms consists chiefly in the smaller size of *Aul. wangenheimi* and in the finer and more erect spines that it bears on the ventral valve.

Aulosteges guadalupensis, Shum., is of the same type, and related as well to *Aul. wangenheimi* as to *Aul. dalhousii;* but this species is so badly figured that it is difficult to decide as to its specific identity or difference with any of the above species. It appears certainly to be much smaller than *Aul. dalhousii.*

2. Aulosteges medlicottianus, Waagen, n. sp., Pl. LXII.

The general outline of this species is more or less trapezoidal, with a moderately vaulted ventral valve which bears a shallow sinus in the middle. The area is comparatively small and the hinge-line long, so that little wings are formed at both ends of it. The dorsal valve is flatly concave throughout, without any spines.

The ventral valve is not much inflated, but its curve is very unequal in different directions. In the longitudinal direction, the valve appears considerably flattened in the apical region till about half way down to the front, when it bends suddenly, but in a well rounded curve, down to the front line. Transversely, this flattening of the apical region is less strongly marked, but then, those parts of the valve which are situated towards both ends of the hinge-line appear considerably flattened, and thus form distinct little wings. The apex is pointed but very little prominent, mostly more or less deformed, but it has never been fixed to a strange body. It is mostly slightly incurved, and thus the area, which extends below, becomes a little concave. This latter is narrow, strongly reclining, and bears a great number

of very strongly imbricating striæ of growth. In the middle it is interrupted by a narrow but very highly roof-shaped pseudodeltidium, which is also provided with many imbricating striæ of growth, but which bears, as far as can be observed, no spines. The median sinus of the valve commences only at a certain, but somewhat variable, distance from the apex. The surface of the valve is covered by not very numerous, tolerably fine spines, which are arranged approximately in quincunx and are erect from their roots. On the wings they are somewhat more numerous and coarser. These spines become often astonishingly long and bend in every direction. They are never straight, and served probably for fixing the valve to foreign bodies.

The dorsal valve is flatly concave, with a very faint indication of a median fold. The apex is very strongly pointed and extremely prominent but quite flat, thus causing the pseudodeltidium of the other valve to assume the shape of a roof. The valve possessess a very narrow vertical area and thus projects like the blade of a knife over the hinge-line. This area, if quite well preserved, possesses a very neat diagonal striation, which starts from the outer and upper margin and proceeds in an oblique direction towards the hinge-line and the base of the cardinal process. The surface of the valve is entirely smooth and devoid of spines, and only a few concentric wrinkles can be observed.

The minute structure of the shell substance of both valves is very much like that of *Productus*. The shell has a dull smooth epidermis, below which follows the proper substance of the shell, which exhibits a very vivid silky lustre. If the epidermis is removed, one sees a very great number of exceedingly fine radial wrinkles, between which punctures are situated. The fine radial striation, which is drawn in the figures on Pl. LXII, is caused by this wrinkling of the deeper shell layers.

Of the interior characters of this species only those of the dorsal valve are to a certain extent known to me. The only specimen, however, in which the interior surface of the dorsal valve is exposed, shows such strange characters that I must suppose that some of them have been brought about by malformation. The cardinal process is very large and depressed, sharp on its dorsal side and broadly flattened on the ventral one. There are no distinct dental grooves at both sides of the base of the cardinal process. On the ventral side, the process is divided by a longitudinal impression, which terminates at the base in a tolerably deep roundish groove, as in most species of *Chonetes*. Below this groove a low median septum takes its origin, which is however in the specimen at my disposal split up in two—a feature that is probably not a natural one, but caused by malformation. This septum extends to not far from the frontal line. The muscular impressions, which are clearly visible, are situated on both sides of this septum. The outer pair of adductors has left large, somewhat reniform dendritic impressions, which reach far up towards the base of the cardinal process. The inner pair is enclosed between the outer pair, and immediately adjoins the median septum: but it is situated lower down, further removed from the cardinal process than the other pair, of

a more narrowly elongated form, and not dendritic. The brachical ridges are not very distinct, but as far as they can be made out, they are of very strange shape. They originate on each side between the muscular impressions, and proceed, slightly ascending towards the hinge-line, to about half way from the shell margin. Then they make a nearly angular bend back, run for a short distance about parallel to the first branch, take a turn towards the front-margin, ascend again in a somewhat parabolic curve, and terminate not far from the point where they originated, in the vicinity of the median septum. The whole internal side of this valve is covered by a fine papillation, which has inadvertedly been left out in the drawing, Pl. LXII, fig. 4*a*.

The measurements of two specimens, No. I from Amb, and No. II from Chidru, are as follow:—

	I.	II.
Entire length of the shell	41 mm.	42 mm.
Length of the dorsal valve	37 „	38 „
Entire breadth of the shell	49 „	50 „
Length of the hinge-line	45 „	33 „
Entire thickness of the shell	23 „	19 „
Distance of the two valves from each other	13 „	16 „
Apical angle of the ventral valve	141° „	149° „

Locality and geological position.—The present species is common only at a single locality, and this is Amb, where it occurs in the coaly sandstones that form the lowest fossilliferous bed of the Productus-limestone above the lavender-clays. I brought away about a dozen specimens. Except at this locality, the species has been found again only at Chidru, by Dr. Oldham; the bed this specimen came from is not exactly known, but it is probable that it came also from the lower Productus-limestone.

Remarks.—It is very easy to distinguish this species from all the others of the same genus that have been described up to the present. From *Aul. dalhousii*, in particular, it can be distinguished by its comparatively larger hinge-line, smaller area, and the less numerous and erect spines.

If we look among other genera, for shells which could possibly be related to the present species, we find *Strophalosia poyangensis*, Kays, from upper carboniferous beds of China, to be rather similar to the Indian shell. It cannot be decided from the plates alone if the Chinese species had better be retained in the genus *Strophalosia*, or if it should not rather be considered as an *Aulosteges*. No point of attachment of the ventral valve seems to exist. But even if the two shells should be found to be congeneric, yet specifically they are certainly distinct. *Stroph. poyangensis* is a much smaller form, with a finer sculpture, shorter hinge-line, and a much more transversely oval outline.

One point in the structure of the Indian species is of special interest,—this is as to how the valves opened. The point on which the dorsal valve turned when the animal opened its shell was the extremity of the apex of this valve, which is strongly prominent, entirely attached to the cardinal process, and sticks

firmly to the roof-shaped pseudodeltidium of the other valve, which is closed nearly quite down to the hinge-line. Owing to this arrangement the valve could not have turned without a slight shifting of the whole hinge-line in a vertical direction, and without a sliding backward of the two thickened projecting shell corners on both sides of the deltidial fissure, which fitted into the large roundish grooves on both sides of the cardinal process without filling them up. Thus it happened that in the position when the valves were opened, the upper margin of the dorsal area was functioning as hinge-line. It is also very remarkable that just in this species, where an opening of the valve was only possible under very peculiar circumstances, the dorsal area possesses a diagonal striation, which bears a striking resemblance to the striation occurring on the valves of the Pelecypoda at the place where the ligament is inserted.

I have thought it not superfluous to draw the attention of men of science to this circumstance, as it would be very desirable that further observations in a similar direction should be made on other shells.

I have given the name of *Aulosteges medlicottianus* to this shell in order to express once more my utmost gratitude to Mr. H. B. Medlicott, the Superintendent of the Geological Survey of India, for the great kindness and untiring zeal with which he has now conducted for years the publication of the present work.

Genus: PRODUCTUS, Sowerby.

This genus is among all the fossils of the Salt-range most numerously represented; I count altogether not less than twenty species of it. Not only are the specific forms so very numerous, but the individuals also occur in the greatest profusion, and in some beds scarcely can any piece of rock be picked up in which one or the other specimen of the genus would not be contained. It was for this reason that I chose the name of "Productus-limestone" for the whole formation.

The genus *Productus* is very well known to everybody, and it seems hardly necessary to repeat here again the already often described generic characters, more especially as I have nothing new to add to them. I have only slightly restricted the genus, inasmuch as I have separated from it those forms which bear in each valve, not far from the margin and parallel to it, a projecting shelly ridge, which is sometimes crenulated on top. I unite these forms under the name of "*Marginifera*," and consider *Productus longispinus*, Sow., also as probably belonging to this genus, though it has the character not yet well developed. All the shells belonging to my new genus are of small size.

Even in this restricted sense there are nevertheless twenty different species that can be attributed to the genus. Seven different species of *Productus* from the Salt-range have been described by Davidson; these are—1, *Productus striatus*, Fisch.; 2, *Productus longispinus*, Sow.; 3, *Productus cora*, Orb.; 4, *Productus semireticulatus*, Mart.; 5, *Productus costatus*, Sow.; 6, *Productus purdoni*, Dav.; and 7, *Productus humboldti*, Orb. I am, however, very sorry to say that I can accept but

few of these names. Firstly, *Productus longispinus* must be removed from the list; as all the forms more or less allied to Sowerby's species occurring in the Salt-range belong to the genus *Marginifera*, and will be treated of later on in this work. With regard to the other species, I must confess that I am inclined to draw the limits of the several species much closer than Mr. Davidson has done, and also closer than Mons. de Koninck has proposed to do. The descriptions of the species in the works of Mons. de Koninck as well as of Mr. Davidson have all been drawn up under the impression that the marine carboniferous species all came from about the same geological horizon,—that is, the mountain-limestone,—and that the marine carboniferous beds of Russia and other countries were not much different in age from those of England and Belgium. In the meantime, Mr. Möller, in a paper of the utmost importance, has shown that the Russian marine beds as well as those of other countries belonged to very different geological horizons,—as different, for instance, as the several sub-divisions of the trias in Southern Europe. While, then, the first of the two views indicated tended to contract the different shapes of Brachiopod shells as far as possible into one species, as of not very much differing geological age, the other takes the very different geological age of the different shapes also into consideration, and must thus arrive at a much closer distinction of the species than would otherwise be the case. I am in this latter position, and must break up the developmental lines of forms, which have all been contracted into one species by Koninck and Davidson, into the several composing members; thus I shall frequently have to apply other names to the Salt-range species than those given by Mr. Davidson. In most cases what is a species for Mr. Davidson is a group of forms for me, but as I always employ the name of the group as heading, it will not be difficult for those who may not agree with my views to reduce them to the opinions of Mr. Davidson.

The grouping of the species of *Productus* has been executed in the most admirable manner by Mons. de Koninck, and in all cases it is most easy to distribute the Salt-range forms into Koninck's groups. Only one of Koninck's groups or sub-divisions I should like to split up into two, namely, that of the "*Striati*," which comprises regular forms like *Prod. cora*, Orb., and *Prod. giganteus*, Mart., as well as the very irregular *Prod. striatus*, Fisch. Now this latter I should like to remove from the group and introduce the designations of "*Lineati*" for the regular forms and "*Irregulares*" for *Prod. striatus* and allies.

If we now go through the different species of *Productus* occurring in the Salt-range, according to the sub-divisions to which they belong, we must begin with the *Lineati* which includes *Prod. cora*. As it seems to me, very different things have been considered as belonging to this species. On a first view, we can distinguish two large groups among the forms that are generally called *Prod. cora*: one group with a median impression on the visceral part of the ventral valve, the group of *Prod. neffedievi*, Vern., and another group without such an impression, that of *Prod. cora* proper. Each of these groups, however, can again be sub-divided, as it appears to me, into several mutations according to the geological age of the

different forms. That the two groups must be considered as distinct has been recognised already by M'Coy and Möller; and notably the latter has not introduced *Prod. neffedievi* among the synonyms of his *Prod. cora*.

In the group of *Prod. neffedievi*, the geologically oldest shape which apparently occurs in the mountain-limestone proper is the typical form which has been figured so excellently by Verneuil (Geol. of Russia, Vol. II, pl. 18, fig. 11) and Koninck (Monogr. d. gen. Prod. et Chon., pl. 5, fig. 2 *d. e.*). This species is characterised by the general absence of spines on the surface of the ventral valve, except along the hinge-line, where apparently two rows of small spines are generally developed. It seems that this form is almost entirely restricted to eastern districts, and is, if not entirely absent, yet very rare in Western Europe. In the upper carboniferous limestone of Russia, chiefly at Mjatchkowa near Moscow, another shape occurs, which has been excellently figured by Trautschold (Mjatchkowa, pl. 5, fig. 1). In this shape scattered spines are generally developed on the surface of the ventral valve, and the hinge-line also bears one or two rows of little spines. This same form occurs in great numbers in the Salt-range. It bears, like the Russian shell, scattered spines on the ventral valve and spines along the hinge-line. I distinguish this form under the name of *Prod. lineatus*, W.

The other group of forms, of which *Prod. cora*, Orb., forms part, has in general a more westerly distribution than the preceding one. The geologically oldest shape of that group is *Prod. corrugatus*, M'Coy, from the mountain-limestone of England and Belgium. Most authors have united this species with *Prod. cora*, but I think it must be kept separate, as in this species by far the majority of specimens is without scattered spines on the surface of the ventral valve, and only in certain rare variations do such spines occur. This shape has been excellently figured by Davidson (Mon. Brit. Carb. Brach., pl. 36, fig. 4, and pl. 42, fig. 9) and Koninck (Mon. gen. Prod. et Chon. pl. 5, fig. 2 *a. b. c.*). The hinge-margin is in this form always provided with numerous spines. In the coal-measures of North and South America, another form occurs, in which the scattered spines on the ventral valve are *never* absent, and in which they occur often in great numbers. This latter form only, I think, must be considered as representing the true *Prod. cora*, Orb. The species has been found also in the Salt-range, but it is very rare there. In America, this species is generally quoted under the name of *Prod. prattenianus*, Norw. and Pratt.

The second of Mons. de Koninck's sub-divisions, of which species occur in the Salt-range, is that of the *Semireticulati*, and it must be remarked that the greatest number of individuals of the genus is furnished by this sub-division. Mr. Davidson has described two species belonging to it,—*Prod. semireticulatus*, Mart., and *Prod. costatus*, Sow. With regard to the first of these two species, I must be somewhat doubtful whether Mr. Davidson had really the *Prod. semireticulatus* from the Salt-range before him, when quoting this species, as *Prod. semireticulatus* is so very rare there that only a single very badly preserved specimen of the species has been obtained up to the present. It is on the other hand probable that

Mr. Davidson has included other forms, which are far more common, but which, according to my views, should be separated from Martin's species, and which I shall describe further on under the name of *Productus spiralis*, W. Another allied form will be described as *Productus aratus*, W. I am in a very similar position with regard to *Prod. costatus*, Sow. The European species is always rather small, not very coarsely ribbed; the most striking character, however, consisting in two thick ribs, which cover the wings of the ventral valve. These ribs, with the strong spines on them, are present in nearly all the specimens, and among a good set of this species contained in the Hof-Mineralien-Cabinet at Vienna, there is not a single specimen without these ribs. The European specimens without the thick lateral folds must be considered as exceptions, which must be traced probably from other sources and might perhaps best be considerd as bastard forms between *Prod. costatus* and *Prod. semireticulatus*. In the Indian shell, which has been identified by Mr. Davidson with *Prod. costatus*, these thick lateral folds are *never* present, and the shell is altogether of a larger and clumsier shape than *Prod. costatus*. I shall call the Indan form *Prod. indicus*, W. At the side of this species another occurs with somewhat finer ribs, which will bear the name of *Prod. subcostatus*, W., and a third with a nearly smooth shell, which will be described under the name of *Prod. vishnu*, W.

With these two groups of forms the species of the *Semireticulati* occurring in the Salt-range are not yet at an end. There is still a very elegant little *Productus*, which I consider as nearly related to *Prod. portlockianus*, Norw. and Pratten. This latter species has been considered by many writers as a synonym only of *Prod. costatus*, but I think it is distinct by its more equal ribs, deeper and sharper median sinus, and smaller size. In all these characters the Indian shell agrees with this American species, but it is yet smaller, the ribs are finer and higher, and thus I must distinguish it under a new name, which will be *Prod. gratiosus*, W. It might perhaps be compared also to *Prod. griffithianus*, Kon.

The third sub-division of Mons. de Koninck, the *Spinosi*, is but very sparingly repesented in the Salt-range. I can place only a single species in this sub-division, and this is rather nearly related to *Prod. muricatus*, Phill., and will bear the name of *Prod. asperulus*, W.

The "*Fimbriati*" occur again in rather large numbers in the Salt-range, and the most important group among them is the group of *Prod. humboldti*, Orb. This latter species itself is rather rare in the Salt-range; so much the more common, however, is another species, which is very nearly related to the preceding one, but distinguished by a coarser granulation, and which will receive the name of *Prod. abichi*, W. Other species belonging to the group, but of less importance, are *Prod. serialis*, W., and *Prod. cylindricus*, W. The group of *Prod. pustulosus*, Phill., is represented by *Prod. bhalensis*. W. Lastly, an isolated species, belonging to the sub-division, is *Prod. purdoni*, Dav.

The "*Horridi*" are but very little developed, whilst the "*Caperati*" are entirely absent. Of the *Horridi* there exists a little spieces, which is very nearly related to

Prod. geinitzianus, Kon., but which yet cannot be identified with that species. It will bear the name of *Prod. opuntia*, W. Another species, also probably belonging to the *Horridi*, appears to bear rather a close likeness to *Prod. kiangsiensis*, Kays, from the upper-carboniferous beds of Lo-Ping in China. Nevertheless I cannot identify the two forms on account of a somewhat different sculpture and a different development of the wings in the Indian shell, and thus this latter will have to take a new name, and I shall call it *Prod. tumidus*, W.

Lastly, the section "*Irregulares*" consists only of shells more or less nearly related to *Prod. striatus*, Fisch. I know that I shall meet with the approval of but very few men of science, when I distribute the forms which are generally considered as composing the species *Prod. striatus*, into several specific groups; and yet I cannot but proceed in the manner indicated. The shells which have been described from the Salt-range under the name of *Prod. striatus* are, to me, distinguishable from the European shell which bears this name, and I must express this distinctness in the name. There are two forms of the group of *Prod. striatus* in the Salt-range. The one has large but depressed wings, so that these latter do not extend approximately in the plane of the valve, but are bent down forming one plane with the lateral descending parts of the apex. This species I shall call *Prod. compressus*, W. The other form is not accidentally but really without wings, and has no hinge-line at all; I shall call it *Prod. mytiloides*, W.

With these latter two species the number occurring in the Salt-range is at an end.

It will be necessary, in order to make a general view of these scattered notices of the affinities of the Salt-range species more easy, to give a classified list of these forms. I have accordingly drawn up the following scheme: —

I.—Section Lineati.

a.—Group of Productus neffedievi, Vern.

1.—*Prod. lineatus*, W.

b.—Group of Productus corrugatus, M'Coy.

2.—*Prod. cora*, Orb.

II.—Section Semireticulati.

c.—Group of Productus semireticulatus, Mart.

3.—*Prod. semireticulatus*, Mart.
4.— „ *spiralis*, W.
5.— „ *aratus*, W.

d.—Group of Productus costatus, Sow.

6.—*Prod. subcostatus*, W.
7.— „ *indicus*, W.
8.— „ *vishun*, W.

e.—Group of Productus portlockianus, Norw. and Pratt.

9.—*Prod. gratiosus*, W.

III.—Section Spinosi.

f.—Group of Productus muricatus, Phill.

10.—Prod. asperulus, W.

IV.—Section Fimbriati.

g.—Group of Productus humboldti, Orb.

11.—Prod. humboldti, Orb.

12.— „ abichi, W.

13.— „ serialis, W.

14.— „ cylindricus, W.

h.—Group of Productus pustulosus, Phill.

15.—Prod. bhalensis, W.

i.—Isolated species.

16.—Prod. purdoni, Davids.

V.—Section Horridi.

k.—Group of Productus geinitzianus, Kon.

17.—Prod. opuntia, W.

l.—Group of Productus kiangsiensis, Kays.

18.—Prod. tumidus, W.

VI.—Section Irregulares.

m.—Group of Productus striatus, Fisch.

19.—Prod. compressus, W.

20.— „ mytiloides, W.

To many it will appear very strange that in this long list only a single species is quoted which occurs also in Europe, and among the whole there are only four, which have been described previously. This result differs widely from what one is wont to see among the *Producti*. In the *Producti* more than in any other group of the Brachiopoda transitional shapes between the several forms occur, and the species are generally taken as having a wider range than those of other groups, their variability being extreme. It will be understood that I cannot here go into details with regard to the European species, though as to them also opinions have been uttered, for instance by Beyrich, that Mesrs. Koninck and Davidson had gone too far in uniting different shapes into one species; but with regard to the Indian forms I must keep things more apart than has generally been done in Europe. The circumstance that we were so very long entirely in the dark as to the general classification of the carboniferous rocks is due in great measure to the very insufficient distinction made among the species of Brachiopoda; and if a satisfactory discrimination of the several marine carboniferous beds is ever accomplished, it will certainly be found that different shapes are also restricted to different beds. The transitional forms that no doubt exist are partly due to the development in time of the different species, although partly also no doubt to hybridity, as I have

indicated already in describing the *Terebratutidæ*. The hybridity will the more frequently occur as the different forms are more nearly related. It seems, however, not practical to lay too great stress on such intermediate forms, but rather the contrary. We will then only arrive at a right understanding of the historical development of the different shapes, by fixing strictly the more constant and frequently occurring forms by separate names, rather than by mingling up different things only for the reason that here and there transitional forms can be observed. Starting from such considerations, I have thus arrived at founding so many new species on the one hand, and on their distinction from the related European forms on the other. The reason why all these forms can be distinguished specifically from all the species that have been described up to the present by other authors, rests probably on two circumstances—first, that the great mass of described *Producti* came from truly carboniferous beds, be it from the mountain-limestone or from the coal-measures; and second, that the Salt-range beds have for the greater part an age different from both.

The geological distribution of the Salt-range species is very variable; some of them are restricted to a single bed, others again extend through the whole Productus-limestone formation. I think it will be best to give here a list of the species with the horisons in which they occur. In this list, Low.=Lower Productus-limestone, Midd.=Middle Productus-limestone, and Upp.=Upper Productus-limestone; Ceph. bed, signifies the Cephalopoda-bed of the Upper Productus-limestone. Thus the distribution of the several species is as follows:—

1. *Prod. lineatus*, W., Midd. and Upp., common.
2. „ *cora*. Orb., Low. Midd. and Upp., rare.
3. „ *semireticulatus*, Mart., Low., very rare.
4. „ *spiralis*, W., Low., common.
5. „ *aratus*, W., Ceph. bed, rare.
6. „ *subcostatus*, W., Midd. and Upp., rare.
7. „ *indicus*, W., Midd. and Upp., very common.
8. „ *vishnu*, W., Midd., very rare.
9. „ *gratiosus*, W., Midd., common; Upp., rare.
10. „ *asperulus*, W., Midd., rare; Upp., common.
11. „ *humboldti*, Orb., Midd., rare.
12. „ *abichi*, W., Midd. and Upp., common.
13. „ *serialis*, W., Ceph. bed, rare.
14. „ *cylindricus*, W., Ceph. bed, rather rare.
15. „ *bhalensis*, W., Low., rare.
16. „ *purdoni*, Davids., Upp., not rare.
17. „ *opuntia*, W., Ceph. bed, rare.
18. „ *tumidus*, W., Midd., rather common; Upp., rare.
19. „ *compressus*, W., Midd., not rare.
20. „ *mytiloides*, W., Ceph. bed, very rare.

It appears from this list that the chief mass of species of *Productus* occurs in the middle Productus-limestone; that the lower Productus-limestone is not very rich

in species, but that those that occur are nearly all peculiar; and that in the upper Productus-limestone the Cephalopoda-bed has the greatest number of peculiar species.

1.—Section: LINEATI.

a.—Group of *PRODUCTUS NEFFÉDIEVI*, Vern.

1. Productus lineatus, Waagen, n. sp., Pl. LXVI, figs. 1, 2, Pl. LXVII, fig. 3.

1862. *Productus cora*, (Orb.) Davidson, Quart. Journ. Geol. Soc., Lond., Vol. XVIII, p 31.
1863. *Productus cora*, (Orb., Davids.) Koninck: Foss. paléoz. de l'Inde, p. 38.
1876. *Productus cora*, (Orb.) Trautschold: Die Kalkbrüche von Mjatschkowa. II, page. 53, pl. V, fig. 1, (Syn. exclus.)

The general outline of this species is mostly elongately oval, longer than it is wide, with a strongly prominent and bent-over apical region. The dorsal valve is not very deeply concave. The sculpture consists of fine radiating striæ, which are interrupted from time to time by not very strong erect spines.

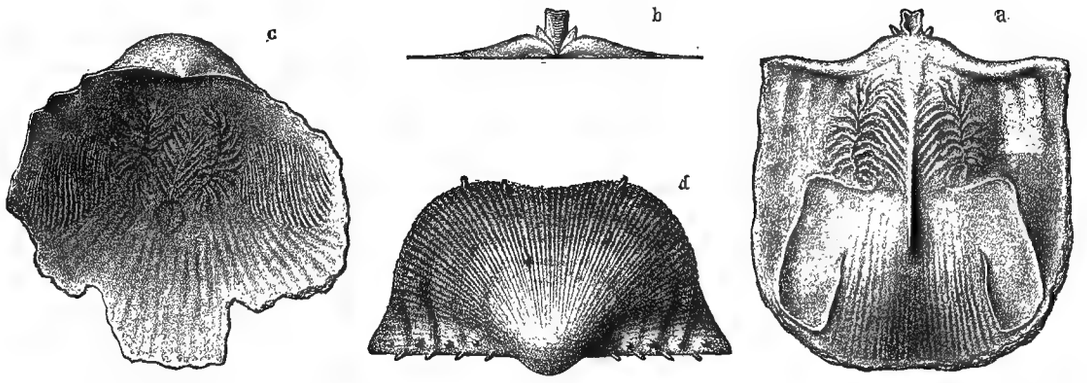


Fig. 21. *Productus lineatus*, W., n. sp.: *a. b. c.* silicified specimen from Musakheyl—*a.* dorsal valve, interior view; *b.* view of the cardinal process and hinge-line from the outer or dorsal side; *c.* ventral valve of the same specimen internal view, all natural size; *d.* cardinal view of a specimen from the road between Vurcha and Uchâli, to show the spines along the hinge-line, natural size.

The ventral valve is very strongly inflated, and it is equally strongly vaulted in both directions. Only, towards the ends of the hingeline it is somewhat flattened, thus forming little spread-out wings. The hingeline is long and straight; but in most cases it is not quite so long as the greatest breadth of the shell. The pointed and very strongly enrolled apex distinctly bends down over it. Not far from the apex, a broad distinct flattening, or impression, appears on the very prominent median part of the ventral valve, and extends as far as the visceral part; lower down, however, it disappears again entirely. The sculpture consists of numerous fine radiating striæ, which remain of very equal thickness for their whole extent, and augment at intervals by intercalation of new ones. There are, very regularly, 7 or 8 striæ within the space of 5 mm. The striæ are interrupted at intervals by the bases of strong erect spines, in which generally three or four striæ unite, and which thus cause locally a

strong deviation of the otherwise straightly descending striæ. These spines are irregularly distributed over the median part of the valve and are rather variable in number, but never very profusely developed. Along the hingeline one or two rows of smaller spines, very irregular in number, are present. The wings are ornamented with strong concentric folds, which are almost entirely restricted to them or only ascend for a very short distance the lateral parts of the median shell portion. The margins of the valve, if entirely preserved—though this is only rarely the case—are not in one plane, but have the lateral parts descending and expanding considerably below the level of the hinge-line, in the same manner as has been described by Trautschold from Moscow specimens.

The dorsal valve is flatly concave in the visceral region, and, when entirely preserved, somewhat geniculated towards the margins. It is most regularly hollowed out in the vicinity of the apex, while the wings are rather flatly spread out. Lower down a very distinct median fold is developed, which is limited on both sides by elongated, deeply excavated spaces. The geniculated part of the valve is again regularly concave. This valve is also ornamented with a very regular fine radial striation, which is, however, rather indistinct on the wings. The striæ are of the same breadth as on the other valve, augment also by intercalation, but are not interrupted by spine-bases, spines being entirely absent in this valve. Instead, a distinct concentric sculpture is developed. This commences on the wings with strong descending folds, which are, however, separated from the hingeline by a smooth excavated space. Of these folds, there are about eight present on each side. They bend round, following approximately the contour of the shell-margin, and unite with the folds of the other side.

The interior characters of the shell are pretty completely known to me. In the ventral valve the muscular impressions are of quite an extraordinary size. The four adductor impressions, as well as the divaricators, are clearly distinguishable. Of the adductors, two large dendritic impressions are situated not far from the apex on both sides of the middle line of the valve, and two quite small ones can be observed at the base of the former and somewhat between them. They are not dendritic. The divaricator impressions are outside the adductors and somewhat lower down. They are very large, of a somewhat broadly reniform shape and strongly striated vertically. The remaining space of the visceral part of the valve, below the muscular impressions, shows shallow radiating furrows which sometimes bifurcate: these might perhaps be explained as impressions of the vascular system.

The dorsal valve is less exactly known to me in its internal characters than the other one, as the space outside the brachial ridges is broken away in the specimen I have for observation, and thus nothing is known to me of possibly occurring vascular impressions, &c. The cardinal process of this valve is comparatively small and little prominent. It is deeply tripartite, the median part being largest, rectangular in shape, and bearing a deep groove on its interior face. The process is supported by a thick callous shelly mass, which forms the upper end of the valve, and is continued along the hinge-margin as thick rounded ridges. Also in the

direction of the middle line of the valve it forms sometimes a thick broadly rounded ridge, which then forms more or less the continuation of the cardinal process. Out of this ridge lower down a high and sharp median septum is produced, extending for about two-thirds of the length of the visceral part of the valve. Where the thick ridge, above mentioned, is absent, the cardinal process is separated from the median septum by an elongated smooth space. The muscular impressions, which are broad but not very long, commence about where the median septum begins. The two pairs of adductor impressions cannot well be distinguished, all forming one large dendritic mass ; it seems, however, that an obliquely striated inner part of the impression belongs to the inner pair, whilst an irregularly dendritic larger outer part may be considered as being produced by the outer pair. The brachial ridges originate at the base between the two pairs of muscular impressions. They first extend outward, slightly ascending, then suddenly bend down and extend in this way, directed slightly outward, for a rather long distance, and at last they turn again inward and upward, and terminate far distant from each other and from the termination of the median septum. The thorns, which generally ornament the inside of the *Productus* shells, seem to be absent in this species.

The species varies to a certain extent, inasmuch as the general outline is sometimes narrowly elongated, sometimes broadly oval. This variation is chiefly due to two circumstances. First, it depends upon the more or less strong development of the wings, which are sometimes rather large and strongly projecting, while they are very small in other cases; and second, from the more or less entire preservation of the " trail," as it as been called,—that is, the part of the shell which is beyond the visceral portion and where the two valves run parallel and nearly touch each other. Another point of variation is in the spines, which are situated along the hingeline. These are sometimes numerous (10 to 12 on each side of the apex) and then arranged in two irregular rows, sometimes they are scarce or seem to be even entirely absent. It must, however, be remarked that these spines are very easily lost by the process of fossilisation, a circumstance which is not the case with the spines scattered over the surface of the ventral valve.

It is barely possible to give exact measurements of this species of *Productus* as the dimensions vary exceedingly with the mode of preservation of the several specimens, and thus exact measurements are of no use for comparison. The largest specimen known to me is 76 mm. in length and 67 mm. in breadth ; its thickness is 53mm. Average-sized specimens have generally 60 mm. in length and 48 to 55 mm. in breadth. The apical angle varies between 85 and 105 degrees. The distance of the two valves in the visceral region is about 30 to 35 mm.

Locality and geological position.—The present species is rather common in certain beds of the Productus-limestone. It commences already in the lower division of the formation, but is very rare there. A single specimen was detected by Dr. Oldham at Chidru in a yellowish-grey sandstone rather low in the series. In the middle division the species has its chief development. It has been found in these beds by all who have visited the Salt-range, and is preserved in the

collections from the following localities: E. of Katwáhí (2 sp.), N. of the same place (1 sp.); Khura (4 sp.); Khura top beds of the middle division (1 sp.); Khund Ghât (7 sp.); Morah (4 sp.); Virgal (2 sp.); Vurcha (3 sp.); road from Vurcha to Uchâli (7 sp.); Musakheyl (2 sp.); Chidru (3 sp.); Káfirkot (6 sp.), Káfirkot North (2 sp.); Paniála cliffs Shekh Budín (2 sp.).

In the upper division of the Productus-limestone the species is somewhat rare. It has been found in these beds by Mr. Wynne at Katwáhí (2 sp.) and at Khund Ghat (1 sp.); and by me on the road between Katwáhí and Shahpur (2 sp.), at Jabi in the *Cephalopoda*-bed (2 sp.), and somewhat lower down (1 sp.), at Chidru in the *Cephalopoda*-bed (1 sp.), and in the section west of Khura, at the base of the upper division.

Remarks.—The occurrence of this species in India is of very high geological interest. As to the identity of the Indian shells with the European one that has been figured by Trautschold, there can, I think, be no manner of doubt. It needs only a comparison of the figures given by me with Trautschold's drawings, to become convinced of the matter. Another question is its distinction from *Prod. cora*, Orb., as these forms are called generally, or from *Prod. neffedievi*, Vern., more especially. I have already stated in the introduction to the genus that, according to my views, the shells which are generally called *Prod. cora* should be divided into two series of forms, one with a median sinus in the visceral region and another without such a sinus. Both of these series have representatives already in the mountain-limestone proper, but these geologically older shells are generally devoid of scattered spines on their shell surface, whilst they bear spines along the hingeline. The absence of spines on the surface of the shell is certainly not entirely due to the preservation of the shell, as has been suggested for *Prod. neffedievi*, by Mons. de Koninck, or else the spines along the hingeline would also be absent. The nearly entire absence of surface-spines is certainly a specific character, and thus the forms with a sinus (*Prod. neffedevi*, Vern.) as well as those without it (*Prod. corrugatus*, M'Coy) must be considered as constituting separate species.

In the upper-carboniferous beds, the upper-carboniferous limestone of Russia, the coal-measures of America, &c., forms with surface-spines occur exclusively. Of shells with a sinus two varieties occur. One of them is that described here under the name of *Prod. lineatus*, W. It is characterised by an elongated general outline, scattered surface spines of varying number, and strong concentric folds on the wings. Another form has been described from the coal-measures of western North America by Meek under the name of *Prod. multistriatus*. It is distinct from *Prod. lineatus*, by a more transverse general outline, a deeper sinus and the absence of concentric folds on the wings. Very nearly related to this American shell are *Prod. impressus*, Toul., and *Prod. weyprechti*, Toul., from permo-carboniferous beds of Spitzbergen. Our *Prod. lineatus* can be distinguished from these by the same characters by which it differs also from *Prod. multistriatus*, Meek.

The forms without a sinus constitute *Prod. cora*, and allied species.

The vertical geological distribution of the several forms is rather large,

The forms without surface-spines seem to go through all the different sub-divisions of the lower-carboniferous, whilst the forms with surface-spines are scattered through the whole of the upper division of the carboniferous formation, without its being possible to distinguish specifically between the forms collected at different horizons. It is a feature which will yet often occur to us in the description of the species belonging to the genus *Productus*, that the species of this genus have a more extensive vertical geological distribution, and that they are not so apt for the characterisation of more minute geological horizons as of larger divisions. For this latter purpose they are often of the utmost value.

b. Group of *PRODUCTUS CORRUGATUS*, M'Coy.

2. Productus cora, Orbigny. Pl. LXVI, fig. 3; Pl. LXVII, figs. 1, 2.

1842. *Productus cora*, D' Orbigny: Voyage dans l'Amérique Méridionale, tome III, 4me partie: Paléontologie, p. 55, pl. V, figs. 8-9.
1852. *Productus cora*, (Orb.) Owen: Geol. Rep. on Wisconsin, Iowa and Minnesota, pp. 103 and 136, pl. 5, fig. 1.
1852. *Productus semireticulatus*, (Mart.) Hall: Stansbury's Rep. Salt Lake Exp., p. 411, pl. III, figs. 3-5.
1854. *Productus prattenianus*, Norw. and Pratten: Journ. Acad. Nat. Sci. Philadelphia, 2 series, Vol. III, p. 17, pl. I, fig. 10.
1855. *Productus aequicostatus*, Shumard: Geological Report, Missouri, p. 201, pl. C, fig. 10.
1858. *Productus cora*, (Orb.) Marcou: Geology of North America, p. 45, pl. VI, fig. 4.
1866. *Productus flemingi*, (Sow.) Geinitz: Carbon. u. Dyas in Nebrasca, p. 52, pl. IV, figs. 1, 2, 3, 4.
1871. *Productus prattenianus*, (Norw.) Meek and Hayden: Final Report on Nebraska, p. 163, pl. II, fig. 5; pl. V, fig. 13; pl. VIII, fig. 10.
1874. *Productus cora*, (Orb.) Derby: On the Carboniferous Brachiopoda of Itaituba, Bull. Cornell Univ., Vol. I, No. 2, p. 49, pl. II, fig. 17; pl. VI, figs. 17.
1875. *Productus prattenianus*, (Norw.) White: Wheeler's Geogr. and Geol. Expl. west of the 100th Meridian, Vol. IV, pl. I; pl. VII, fig. 1.
1877. *Prod. prattenianus*, (Norw.) Meek: King's Geol. Expl. of the 40th Parallel, Vol. IV, p. 72, pl. VII, fig. 7.

The general outline of this species is elongately to transversely oval. The ventral valve is moderately convex, with a not very strongly prominent apical region. The dorsal valve is not very deeply concave, geniculated. The sculpture consists of a fine radial striation, with tolerably numerous scattered spines on the surface of the ventral valve.

The curve of the ventral valve is rather different in different specimens. In some the apical region is somewhat flattened in the longitudinal direction, whilst it is regularly vaulted in others. In the transverse direction the curve is everywhere regular. The lateral parts along the hingeline are flattened and form rather largely spread-out wings, which are however rarely entirely preserved. The hingeline is as long or slightly shorter than the greatest breadth of the shell. The apex is nearly always strongly enrolled, slightly prominent, pointed, and generally overhangs the hingeline a little. The wings are flatly spread out, and bear not very strongly developed concentric folds or wrinkles, of which there are about four or five on each wing. When the valve is entirely preserved, it possesses a well-developed trail, which is in some cases spread out all round the shell, but which mostly does not deviate from the general curve of the valve. The sculpture of the valve consists in fine radiating ribs, which are

separated from each other by equally broad interstices. The striæ are nearly of equal breadth for the whole length, and vary in this respect only so far, that there are seven of them within the space of 5 mm. not far from the front margin, while there are ten within the same space in the vicinity of the apex. From distance to distance this striation is interrupted by the bases of strong erect spines which are irregularly disseminated over the surface of this valve. Their number is rather large; I counted 24 such spines on a specimen from Jabi. At the base of these spines four to six of the longitudinal striæ unite. Along the hinge-margin also numerous spines exist which are, however, smaller than the others.

The dorsal valve is not very deeply concave in the visceral part, and geniculated where the trail commences. The wings are large and quite flattened, separated from the remainder of the valve by barely perceptible rounded ridges, which diverge from the apex to the lateral parts of the shell. The sculpture of the valve consists of radial striæ of the same character as those of the other valve. Of scattered spines, or grooves corresponding to the spines of the other valve, nothing can be seen. Besides this radial sculpture there is also a concentric one, consisting of rather irregular concentric folds or wrinkles, which are apparently sometimes in connection with somewhat imbricating or even lamellar striæ of growth.

The internal characters of this species are not known to me.

The size of the species is moderate; it seems not to become as large as *Productus lineatus*. The visceral part of a full-grown specimen is about 55 mm long, 50 mm. broad, and 30 mm. thick. The distance of the two valves from each other is about 23 mm.

Locality and geological position.—This species is extremely rare in the Salt-range, though it occurs off and on through the whole vertical extent of the Productus-limestone formation. Most numerously I found the species in a reddish sandstone at the very base of the fossiliferous part of the Productus-limestone at Katta (bed No. 9 of my note-book). The specimens are mostly very badly preserved, but I brought away four, tolerably well preserved and well determinable. In the middle division of the Productus-limestone the species has been detected up to the present only trans-Indus; Mr. Wynne brought one specimen from Omarkheyl and one specimen from Shekh Budín. The upper division has furnished two specimens at Jabi, where they occurred in the *Cephalopoda*-bed.

Remarks.—I must at first say some words about the name I apply to this species. The original figure of the species, as given by D'Orbigny in his Voyage dans l'Amérique Méridionale, cannot possibly be correct. The wings as they are drawn could never occur in any *Productus;* they are represented like the wings of a *Janira* or some such form. If then we consider the figure, we must ignore the wings entirely, and notice only the body of the shell in comparing the figure with other species. Now Mons. de Koninck tells us, after inspection of the original specimen, that *Productus cora* is in every respect identical with *Productus corrugatus*, M'Coy, with the sole exception that the surface is spiny, whereas in the European shell it is generally devoid of spines. That Mons. de Koninck does not think this difference to be of sufficient importance to distinguish specifically between

the American and the European forms, does not materially influence the question. We know from Mons. de Koninck's observation, which is not directly contradicted by D'Orbigny's figure, how to interpret that figure, and from such an interpretation it devolves necessarily that the form described by American writers generally under the name of *Productus prattenianus*, Norw., is identical with *Productus cora*, Orb. A further argument in the matter can be drawn from Mr. Derby's statement, that the beds in which *Productus cora* at Yarbichambi occurs are to all appearances of the age of the coal-measures.

Thus the true *Productus cora* would be constituted of those forms which have been called in North America *Productus prattenianus*, but it would be entirely absent in Europe and the adjacent countries. Of European forms which approach very nearly *Prod. cora*, one must chiefly be mentioned, that figured by Möller from the upper carboniferous-limestone of the Ural under the name of *Prod. cora*, Orb. (Mining Journal of St. Petersburg, 1862, p. 179, pl. IX, fig. 3), and of which somewhat smaller specimens subsequently received the name of *Prod. riparius* from Trautschold. Though the latter author affirms in his description of the species that there were no scattered spines on the surface, yet he draws three spine bases on the figure of his original specimen. This *Productus riparius*, Trautsch., very likely replaces the *Productus cora* in the upper-carboniferous beds of Europe, and can be distinguished from the latter species by its flat (not enrolled) form, pointed and prominent beak, and the median impression far away from the beak, as in most specimens;—such are the characters as far as can be judged from drawings and descriptions, no specimens being at my disposal.

Less nearly related is *Productus corrugatus*, M'Coy. I have already stated above that I consider this species as distinct on account of the general absence of spines on the surface, whereas these spines are *never* absent in *Prod. cora*. Otherwise *Prod. corrugatus* shows the same configuration and the same inflation of the ventral valve.

A whole group of forms in outward appearance having a certain similarity to *Prod. cora* has lately been made known by Dr. Stache from carboniferous beds of the Sahara. The chief representative of this group is *Prod. africanus*, Stache. The internal characters of these forms are however so peculiar that it will probably prove necessary in time to create a proper genus for their reception. They need not then be compared more particularly with *Prod. cora* and its allies.

II.—Section SEMIRETICULATI.

c. Group of *PRODUCTUS SEMIRETICULATUS*, Mart.

3. Productus semireticulatus, Mart.

1847. *Productus semireticulatus*, (Mart.) Koninck: Monogr. des genres Productus et Chonetes, p. 83, pl. VIII, fig. I; pl. IX, fig. 1; pl. X, fig. 1.

1862. *Productus semireticulatus*, (Mart.) Davidson: Quart. Journ. Geol. Soc., Lond., Vol. XVIII, p. 31.

1863. *Productus semireticulatus*, (Mart. Davids.) Koninck: Foss. paléoz. de l'Inde, p. 38.

1863. *Productus semireticulatus*, (Mart.) Davidson: Monogr. of Brit. Carb. Brach. p. 149, pl. XLIII, figs. 1-11; pl. XLIV, figs. 1-4.

1866. *Productus semireticulatus*, (Mart.) Davidson: Quart. Journ. Geol. Soc., Lond., Vol. XXII, p. 43, pl. III, fig. 12.

1871. *Productus semireticulatus*, (Mart.) Quenstedt: Petrefactenkunde Deutschl. Abthlg. I, Vol. II, p. 621, pl. XXVIII, figs. 29-41.

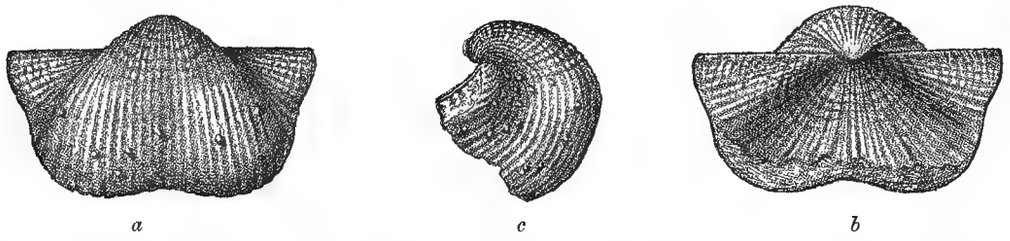
1871. *Productus semireticulatus*, (Mart.) Meek and Hayden: Final report on Nebraska, p. 160, pl. 5, fig. 7.

1874. *Productus semireticulatus*, (Mart.) Derby: Bull. Cornell Univ., Vol. I, No. 2, p. 47, pl. IV, fig. 8; pl. VI, fig. 18; pl. VII, figs. 5, 6, 7, 15, 16.

1877. *Productus semireticulatus*, (Mart.) Meek: Clarence King's Geol. Explor. of the 40th Parallel, Vol. IV, p. 69, pl. VII, fig. 5.

1883. *Productus semireticulatus*, (Mart.) Kayser: Obercarbonische Fauna von Lo-Ping, in Richthofen's China, Vol. IV, p. 181, pl. XXV, figs. 1-4 and 7.

I have given here only a few of the quotations which might be given with respect to the present species, but those adduced are sufficient to show what I mean to understand by the name.



a *c* *b*

Fig. 22. *Productus semireticulatus*, Mart. Fragmentary specimen from the lowest fossiliferous beds above the lavender-clay of the Chittawán near Ghari: *a*. ventral view; *b*. dorsal view; *c*. lateral view; all natural size.

There is a single very badly preserved specimen in the Salt-range collection that may possibly be united with Martin's species. It is semireticulate in its apical region, and bears on the frontal and lateral parts of the ventral valve about 50 narrow sharp radiating ribs. On these ribs thin erect spines are disseminated; they are chiefly numerous in the depressions by which the wings are marked off from the body of the shell. The median sinus is rather deep and narrow, but the general form of the specimen is a good deal altered by pressure, and thus the general features of the relief cannot be much relied upon.

To give a more accurate description of the specimen seems not advisable, as it is too badly preserved. The subjoined woodcut gives a sufficient clear idea of its features.

Locality and geological position.—I should not have mentioned this specimen, but that its geological position is peculiar, and that it would from this circumstance be of more than common interest. The specimen was collected by myself in the Chittawán near Ghari, in blackish sandstones forming the very lowest fossiliferous beds of the Productus-limestone above the lavender-clays. Thus the species occurs very rarely in the lowest fossilferous beds, and is entirely absent in all the other beds of the Salt-range.

Remarks.—*Prod. semireticulatus* is one of the most characteristic carboniferous species, and is not restricted to a single bed or country, but extends vertically

from the lowest beds of the mountain-limestone up to the transition beds between permian and carboniferous, and horizontally it is spread over the whole world. So much the more it is surprising to find so much difficulty in the endeavour to detect the true *Prod. semireticulatus* among the fossils of the Productus-limestone.

It follows from the quotations at the head of the description of this species that I take it in the broadest sense, so that all the forms with numerous narrow radiating ribs fall within its scope. In this sense the specimen here described must receive the name of *Prod. semireticulatus*, Mart.; it is decidedly distinct from all the other 'semireticulate' *Producti* occurring in the Salt-range by its sharp narrow ribs, which amount to the number of 50. It is true this number is not identical with that occurring in typical specimens, but there occur also in Europe varieties having less numerous ribs than the typical form, and which yet cannot be kept separate from the latter. The Indian specimen resembles extremely closely the specimens from Visé, figured by Quenstedt (Petrefactenk. Deutschl., Brach., pl. 58, fig. 38) under the name of *Prod. sulcatus*, but which probably must yet be united with *Prod. semireticulatus* on account of the absence of the thick, lateral, spine-bearing ribs, characteristic of the true *Prod. sulcatus* and *costatus*. Thus it seems to be a well-established fact that the specimen here under consideration on the one hand very closely agrees with *Prod. semireticulatus*, and is on the other hand unique among the forms occurring in the Salt-range.

This sporadic occurrence of this well-known extremely characteristic and widespread carboniferous species just in the lowest fossiliferous beds of the Salt-range is of high geological interest. The species is very common in the carboniferous beds of the Himalaya, and it is highly probable that the great scarcity of *Prod. semireticulatus* in the Salt-range indicates a difference in age of the beds occurring there. We have seen from the description of the fauna up to the present that in the lower division of the Productus-limestone many forms of permian habitus, the *Strophalosiæ*, *Aulosteges*, &c., are mixed with truly carboniferous types like *Reticularia lineata*, &c.; with these occur the *Fusulinæ*, which are entirely restricted to the lower division. All these facts, together with the sporadic occurrence of *Productus semireticulatus*, conduct to the conclusion that the homotaxial position of the lower division of the Productus-limestone of the Salt-range must be about equal to the uppermost beds of the coal-measures of North America.

4. Productus spiralis, Waagen, n. sp., Pl. LXVII, fig. 6; Pl. LXVIII, fig. 3; Pl. LXIX, figs. 1, 2, 3.

It is a rather large species that I distinguish under the above name, the largest species of *Productus* occurring in the Salt-range.

The species is most strikingly characterised by its very strongly inflated and enrolled ventral valve, and chiefly by the large, narrow, spiral wings at the ends of the hingeline.

The ventral valve is very strongly inflated, but of a very equal curve throughout. Longitudinally the curve forms a very regular open spiral, and transversely it forms a high arch, which is somewhat impressed on top, and flattened on both sides towards the wings. The apex is pointed, little prominent, and overhangs the hingeline but very little, though it is so strongly enrolled. The hingeline is straight and always occupies the greatest breadth of the shell. Along the hingeline in some specimens a very distinct and sharply defined area is developed, but strange to say this area is then often provided with thickly strewn, irregularly arranged, short sharp spines. The wings on both ends of the hingeline are very strongly prominent. They are narrow and spirally enrolled. The visceral part of the valve projects far above the wings, and bears a strong sinus in the middle, which commences a short distance from the apex and extends over the trail down to the front margin. The sculpture consists of strong radiating ribs, crossed in the vicinity of the apex by a system of concentric plications, which extend for a distance of 48 mm. to 60 mm. from the apex, measured along the curve. The crossing of these two systems of sculpture causes a very neat reticulation of this part of the shell. The radial costæ are thick and strongly prominent, but on the whole rather regular. They are somewhat thicker in the middle of the valve than on the wings. There are four such costæ in the middle in a space of 10 mm., whilst there are five in the same space on the wings. Some of the radial costæ disappear bye-and-bye in the depth of the median sinus as it becomes narrower and deeper on approaching the frontal margin. On the radial ribs large erect spines are irregularly disseminated. They are more numerous on the wings and along the hingeline than elsewhere. The furrows between the ribs are much narrower than the ribs themselves.

The dorsal valve of the species is only partially known to me, as it is covered in most of the specimens at my disposal by firmly adhering rock-matter. This valve is flatly concave in the visceral portion, bears a strongly prominent median fold towards the front, and is very strongly geniculated where the trail commences. The wings are large and strongly excavated. The hingeline is long and straight, and there often extends along it a narrow but very sharply defined area, which is, however, never provided with spines. The sculpture consists up to the commencement of the trail of a very neat reticulation, which is in every respect the reverse of the reticulation of the other valve. From this sculpture the wings are exempt; they are nearly quite smooth or bear only irregular concentric wrinkles. On the trail or geniculated part of the valve, the sculpture consists only of coarse radial costæ. No erected spines have been observed by me on this valve.

Of the internal characters of this species only those of the dorsal valve are known to me. The cardinal process is extremely short and broad. It is trifid at its upper extremity, and its lateral branches are larger than the median one, which is broad and bears a little groove in the middle. From the process there extend two blunt lateral ridges down to the hingeline. In the middle the process is joined to a broad median elevation, which changes into a narrow, little elevated septum where it extends between the muscular impressions. These latter are large and dendritic

situated in rather deep grooves. The two pairs cannot well be distinguished. The brachial ridges are very peculiar. They originate about in the middle of the base of the muscular impressions, then ascend along this base up to the outer corner of it, are then suddenly deflected, descend in the direction of the front and form a large hook. A returning branch towards the middle line of the valve cannot be observed. The whole internal surface of the valve is covered by irregular asperities, but no long thorns seem to exist.

The measurements are approximate, from a specimen with partly preserved "trail" from Swás, as follow :—

Length of the shell in a straight line	71 mm.
„ „ along the curve	150 „
Length of the hingeline	86 „
Thickness of the ventral valve	43 „

Locality and geological position.—This species is the only true *Productus* which occurs somewhat plentifully, in some places even in great numbers, in the lower divisions of the Productus-limestone. It is, however, difficult to extract these large shells in tolerably well preserved specimens from the rock, and thus it happened that not very many specimens of the species are preserved in the Salt-range collection. Specimens of the species were brought by Mr. Wynne from the Verála springs (3 sp.), from Chidru (1 sp.), from Golawáli (2 sp.), from Swás (2 sp.), and trans-Indus from Omarkheyl (7 sp.). I have myself collected the species (3 sp.) in the Chittawán, in the coaly sandstones together with *Spirifer niger*, and at Amb in the so-called *Chonetes*-bed (1 sp.).

Remarks.—The present species is no doubt very nearly related to *Prod. semireticulatus*, Mart., and it is not quite certain whether the shells quoted by Davidson under this latter name from the Salt-range, do not rather belong to *Prod. spiralis* than to Martin's species.

It is however not difficult to distinguish the present form from the true *Prod. semireticulatus*. The most striking distinguishing characters are the much coarser and less numerous radiating ribs, the beautifully spirally enrolled general outline, and the long narrow wings, which form nearly a spirally enrolled tube. All these characters do not occur in *Prod. semireticulatus*, and I have no doubt that they are sufficient to distinguish the present form specifically from Martin's species. To these external characters come yet the internal ones, and if we compare the drawing given by Davidson of the interior of the dorsal valve of *Prod. semireticulatus* with my drawing on Pl. LXIX, fig. 6, there cannot, I think, remain the slightest doubt that the two figures represent two different species. Of the European forms that have been described up to the present, the one figure by Grünewald (Beiträge, pl. III, fig. 1) from Saraninsk most nearly agrees with the shell here under description, only the radial striation is somewhat finer.

Of species occurring in other parts of the world, only the South American *Prod. boliviensis*, Orb., shows a certain similarity to the form here under consideration. It has similarly, long, narrow and spirally enrolled tube-like wings, but it differs from the Indian shell by its very fine radial striation.

5. Productus aratus, Waagen, n. sp., Pl. LXXII, figs. 1, 2.

The chief characters of this species consist in a more or less transversely rectangular general outline, a very shallow and broad sinus in the middle, and very broad rounded radiating ribs in the frontal part of the ventral valve. The characters of the dorsal valve are not at all known to me.

The ventral valve is strongly curved and inflated, but its curve is rather irregular. The apex is strongly bent in, then comes a somewhat flattened part, which extends as far as the reticulate portion of the valve, and then a blunt geniculation takes place, the remainder of the shell being regularly curved. This is what can be observed of the curve in the longitudinal direction. In the transverse direction the curve is rather regular, only somewhat depressed in the middle. Laterally the valve is somewhat spread out, forming rather large vaulted wings, which are distinctly separated from the remainder of the shell. The apex is pointed, little prominent, and barely at all overhangs the hingeline. This latter is long and marks always the greatest breadth of the shell. Not far from the apex a broad but very shallow sinus commences, which extends down to the front. The sculpture of the valve consists of two systems of plications which are both rather coarse. The concentric plications are restricted to the vicinity of the apex, and extend from there up to a distance of 38 to 43 mm. measured along the curve. The radial plications are of very unequal thickness on different parts of the shell. On the reticulated part, where they are crossed by the concentric folds, they are rather thin, not thicker than these. Lower down, however, mostly two of the plications unite and form one broad rounded fold. These folds extend all parallel to each other down to the front. There are not more than two to three of them within the space of 10mm. On these radial folds there are many large erect spines irregularly disseminated all over the shell; they are not more numerous on the wings, or in the vicinity of the hingeline than elsewhere. There is no rib more strongly developed which would mark off the wings, nor are there more strongly developed or more numerous spines in its place. This indicates clearly that we have to deal here with a form belonging to the group of *Productus semireticulatus*.

Though in all the specimens at my disposal the dorsal valve is preserved, yet I have not succeeded in cleaning it. I can only say that it is strongly geniculated, the visceral part extending not much further than the reticulated part of the ventral valve. All the remainder belongs in both valves to the "trail."

The internal characters of both valves are unknown to me.

The measurements of a specimen are approximately the following:—

Length of the ventral valve in a straight line	44	mm.
„ „ „ „ „ along the curve	94	„
Length of the hingeline	65	„
Thickness of the ventral valve	34	„

Locality and geological position.—This species is very rare in the Salt-range and has been detected there up to the present only at a single locality and in a

single bed. I collected two specimens in the *Cephalopoda*-bed at Jabi (upper Productus-limestone).

Remarks.—The present species is very easily distinguishable from *Prod. semireticulatus*, to which it is most nearly related, by its very coarse parallel radial ribs. From *Productus spiralis*, W., described above, the present species can well be distinguished on a first glance by its very broad shallow sinus and much smaller size. These characters seem to me sufficient to distinguish the form here under consideration as a separate species with a proper name.

d. Group of *PRODUCTUS COSTATUS*, Sow.

6. Productus subcostatus, Waagen, n. sp., Pl. LXVII, figs. 4, 5; Pl. LXVIII, figs. 1, 2; Pl. LXIX, fig. 4.

This species is always of a moderate size, and never becomes very large. It has a roundish or somewhat transversely oval outline, and the hingeline always occupies the greatest breadth of the shell. The wings are small but distinct, the median sinus is rather deep and not very broad. The sculpture consists of from 25 to 30 rather strong radial ribs, which are all tolerably equal in strength.

The ventral valve is rather strongly inflated and tolerably regular in its curve in the longitudinal direction as well as in the transversal one. The apex is pointed, very little prominent, and barely at all overhangs the hingeline. This latter is straight and always occupies the greatest breadth of the shell. In the majority of specimens it is provided with a narrow but very sharply defined area, which is cut open in the middle by a small deltidial fissure. This area is often provided with an oblique somewhat granular or spiny striation, similar to the striation which has been described above on the area of the dorsal valve of *Aulosteges medlicottianus*, W. On both ends of the hingeline small but distinct vaulted wings are developed, which are separated from the remainder of the shell by a row of spines, situated on a slightly thickened radial rib. At a very short distance from the apex the median sinus commences. In the beginning it is somewhat flattened, but soon it becomes deep and comparatively narrow, and extends in this way down to the front. The sculpture consists of two systems of folds, which are of about equal strength, one concentric, extending to a distance of about 34 to 37 mm. from the apex, measured along the curve, and one radial, the folds of which extend down to the front. The vicinity of the apex becomes thus finely reticulate as in the other allied species. The radial folds are 25 to 30 in number. They are not all of quite equal strength, but tolerably so. There is on each side one slightly more strongly developed rib, marking off the wing from the remainder of the shell. This rib bears always three to four very strong and long spines. The reticulation extends over these spine-bearing ribs as well as over the whole wings. Over the whole surface of the valve very long and strong spines are scattered, always situated on top of longitudinal ribs.

The dorsal valve is very regularly concave with a not very high median fold in the frontal region of the visceral part, extending over the trail down to the shell-margin. The wings are spread out and flatly concave. Also in this valve very often a linear area exists. When this is the case, the apex of the valve is produced, and fills up the deltidial fissure of the other valve. The whole apparatus has, on a small scale, much the appearance of the same parts of *Aulosteges medlicottianus*, W., and suggests the probable existence of a ligament.

The sculpture of the valve consists in a very strong reticulation which extends as far as the visceral part of the valve. On the trail only the radial ribs exist, while on the wings they disappear and only the concentric wrinkles remain. The most singular feature of the valve consists in some three or four deep grooves on each side, situated on the prominent ridges that separate the deeply excavated median part of the valve from the wings; these grooves correspond to the strong spines which are to be found on the other valve, on that slightly more strongly prominent radial rib which occurs at the limit between the wings and the remainder of the shell. The valve bears no traces of any spines.

The interior characters of both valves are unknown to me.

The measurements of a specimen with preserved trail from Khund Ghat are approximately as follow :—

Length of the shell in a straight line	47 mm.
„ „ „ „ along the curve	90 „
„ „ „ „ from the apex to the front margin	35 „
Length of the hingeline	54 „
Thickness of the ventral valve	30 „

This is the largest specimen known to me. The other specimens are mostly somewhat smaller.

Locality and geological position.—This is a rather rare species, and has been found up to the present only in sporadic specimens scattered equally through the middle and upper divisions of the Productus-limestone. In the middle division it has been collected by myself at Káfirkot (2 sp.), and I had found it previously in the upper division at Nanga (1 sp.). Mr. Wynne brought one specimen from the upper division of Khund Ghat, and two specimens from the same division north of Káfirkot.

Remarks.—I for a long time considered the present species as identical with *Prod. sumatrensis*, F. Roemer, but after a lengthened and careful consideration of the matter I came to the conclusion that the two must be different, and the Indian shell must receive a new name. It is much to be regretted that the description by Roemer is so very short, and the figures apparently more or less diagramatic, and thus it is rather difficult to decide on questions relating to this species. In treating the matter I have started from the consideration that such an excellent connoisseur of palæozoic fossils as Geheimrath Roemer would most certainly have compared his species with *Prod. costatus* and not with *Prod. semireticulatus*, if in this shell a row of spines were situated on a somewhat prominent radial ridge separating the

wings from the remainder of the shell. But as he entirely omits to speak of *Prod. costatus* and compares his shell solely with *Prod. semireticulatus*, it must be taken for granted that there exists no affinity with the first of the two species, and that in reality no such row of spines as has been indicated above nor on the whole a greater number of spines are present. If this be the case Roemer's species cannot be identical with the Indian shell here under consideration. Other points of difference between *Prod. sumatrensis*, Roem. and *Prod., subcostatus*, W., consist in the greater curvature of the ventral valve and the larger and more contorted wings of the latter species, also the age of the two forms seems different. *Productus sumatrensis* occurs together with many *Fusulinæ* and *Schwagerinæ*, whilst *Prod. subcostatus* appears in the first specimens only *above* the *Fusulina* beds.

Next in affinity comes *Productus costatus*, Sow. We must take for comparison the typical form of this species which is represented by Davidson on Pl. XXXII, figs. 2, 3, 4 of his Mon. Brit. Carb. Brach., or by Koninck in his Monographie du Genre Productus, Pl. X, figs, 3 *a*, *b*, *c*, *d*. This typical form is very easily distinguishable from our Indian shell by the enormously strongly developed radial rib, which separates the wings from the body of the shell, and by the non-extension of the reticulation on the wings. This typical form seems also the predominating one in the mountain-limestone of England and Russia Among many specimens of the species contained in the Hof-Mineralien-Cabinet in Vienna only this typical shape is represented. Together with this typical form, however, in England as well as in Russia other shapes occur, which also have been figured by Davidson and Koninck. As far as my opinion goes, these other forms very probably should be considered for the greater part as hybrids either between *Prod. costatus* and *Prod. muricatus*, Phill., or between the former and *Prod. semireticulatus*, Mart. Howsoever this may be, the Indian shell can be distinguished from these forms by its much robuster form and size and a much larger reticulated part of the shell, which occupies in general 37 mm. in the length, measured along the curve, whilst the same part in the varieties of *Prob. costatus* just mentioned measure only 30 mm.

I thus think myself justified in considering the shell here under consideration as a distinct species, though very nearly related to *Prod. costatus*.

7. Productus Indicus, Waagen, n. sp., Pl. LXX, LXXI, fig. 1.

1862. *Productus costatus*, (Sow.) Davidson : Quart. Journ. Geol. Soc., Lond., Vol. XVIII, p. 31, pl. I, figs. 20-21.

1863. *Productus costatus*, (Sow., Dav.) Koninck : Fossiles paléoz. de l'Inde, page 38, pl. X, figs. 20-21.

The present species is very nearly related to the preceding one. It can be distinguished from the latter by its generally larger size, more irregular ribbing and the absence of the somewhat more prominent rib, which would divide the wings from the remainder of the shell.

The ventral valve is very strongly convex, nearly spirally enrolled. Longitudinally a slightly flattened space can be observed not far from the apex, and also the trail is again somewhat flattened. In the transverse direction the visceral part of the shell appears well elevated above the hingeline, but the curve is regular, only in the middle somewhat impressed. The wings are large, prominent, and vaulted. The hingeline is straight, long, and marks about the greatest breadth of the shell. The apex of the valve is pointed, not much prominent, and overhangs but very little the hingeline. Very near to the apex a strong and deep median sinus commences, and extends down to the front. The sculpture consists of two systems of folds, one concentric and one radial. The concentric folds are very equal in size, and extend partly also over the wings. They cover a space of 43 to 45 mm. from the apex, measured along the curve. The radial ribs are only regular so far as the concentric sculpture extends; further on they become very irregular, some thick, some thin, two and more unite often into one rib, &c. Chiefly in the depth of the sinus several ribs often disappear entirely, and the others converge then towards the front to take up the place of those that have disappeared. Over the whole surface of the valve numerous long erect spines are irregularly distributed. Only four of these spines on each side of the apex have a position in which they are very regularly to be met with. They are situated in the furrow that separates the wing from the remainder of the shell, but are not placed on a radial rib, they seem rather to be in connection with the concentric sculpture.

The dorsal valve is but rarely observable, as it is mostly covered up by rock matter. It is flatly concave in the visceral region and somewhat geniculated where the trail commences. In the middle it bears a little elevated median fold. The wings are flatly spread out and slightly concave. The valve is nicely reticulated on the visceral part. The concentric folds are present on the wings only, and the radial ones only on the trail. On the ridge which separates the wings from the remainder of the valve three or four flat grooves are present, corresponding to strong spines on the other valve.

The interior characters of both valves are well known to me. The inner side of the dorsal valve has been figured already by Mr. Davidson, and I have given on Pl. LXX, figs. 5 and 6, the drawings of two other specimens. The cardinal process is tolerably prominent, and rests on a very broad base. It is distinctly trifid, the median lobe being again sub-divided by a longitudinal groove. The base extends laterally into thickened ridges, which run down to both ends of the hingeline. On the median face of the base a low rounded ridge originates extending to about the middle of the muscular impressions, and then splits into two, leaving open in the middle a deep fissure in which the median septum of the valve originates. This septum extends as far as the visceral part of the valve and suddenly terminates, where the valve begins to become geniculated. The muscular impressions are rather variable in size. They are very large in the specimen represented in fig. 5, and much smaller in the specimen fig. 6. The two pairs of impressions can never well be distinguished. The brachial ridges originate not far from where the median

septum commences, pass in a nearly horizontal direction far out towards the lateral margins of the valve, then suddenly turn down, inward and up again, forming thus a very distinct hook. They terminate far away from the median septum, no returning branch being developed. There is a distinctly smoothened and somewhat excavated space in front of the horizontal branch of the brachial ridges, which extends on the one side into the hook-shaped part of these ridges, on the other runs down along the median septum nearly to the end. All the remaining parts of the interior face of the valve are covered with a fine granulation, whilst at the same time a great number of fine pores is disseminated between the granules.

The ventral valve has raised dendritic muscular impressions, not far from the apex, divided from each other by a deep furrow. They belong to the adductors. The divaricators are situated outside and below the former, and are, as usual, larger and striated longitudinally.

The dimensions of the species are rather variable. The largest specimen known up to the present is that figured by Davidson (Quart. Journ., Geol. Soc., Lond., Vol. XVIII., pl. I, fig. 20). Slightly smaller is the specimen figured by me, Pl. LXX, fig. 1. The average size of the specimens occurring in the Salt-range is represented by fig. 2 of the same plate. The measurements of the largest specimen known to me, and of an average-sized specimen, are as follow :—

	I.	II.
Length of the shell in a straight line	50 mm.	45 mm.
„ „ „ along the curve	102 „	84 „
Length of the hingeline	64 „	52 „
Thickness of the ventral valve	32 „	30 „

Locality and geological position.—This is the commonest species of the Salt-range. It is, however, restricted to the middle and upper divisions of the Productus-limestone, and is absent in the lower division.

It is preserved in the Salt-range collection from the following localities: From the middle division from Katwáhi (7 sp.), from Khund (11 sp.), from Chidru (8 sp.), from the road between Vurcha and Uchâli (9 sp.), from Khura (2 sp.), from Vurcha (1 sp.), from Virgal (1 sp.), from Musakheyl (5 sp.), from Mora (6 sp.), from the Chittawán (3 sp.), from Kálabágh (10 sp.), from Budikheyl (2 sp.), from Bilot (1 sp.), from Káfirkot (33 sp.), from the Paránga Kuss (1 sp.), and from the Paniála Bluffs at Shekh Budín (6 sp.).

The upper division has furnished specimens at Khund Ghat (17 sp.), at Khûra (5 sp.), at Kufri (1 sp.), at Jabi (Cephalopoda-bed 5 sp., lower beds 1 sp.), at Chidru (Cephalopoda-bed 4 sp.).

Remarks.—The present species is very nearly related to the one described before. It can chiefly be distinguished from the latter by its generally larger size and much more irregular radial ribbing, also by the absence of the characteristic radial rib separating the wings from the remainder of the shell.

The form here under consideration has been united by Davidson with *Prod. costatus*, Sow., but in reality it appears less nearly related to that species than to

Prod. subcostatus, W., described before. It can be easily distinguished from Sowerby's species by the constant absence of the thick rib which extends in *Prod. costatus* between the wing and the remainder of the shell. Among hundreds of specimens I have seen, there was not a single one which in this respect would have resembled the typical *Prod. costatus*. This constant dissimilarity in connection with the larger size and less transverse shape of the Indian shells indicates, I think, beyond doubt the existence of a species in India different from *Prod. costatus*. I am even in doubt whether the present species should not, according to its characters, be altogether removed from the group of *Prod. costatus*, and transferred to the group of *Prod. semireticulatus*.

Prod. sumatrensis, F. Roem., which also might be compared, is finer and more regularly ribbed than *Prod. indicus*.

There is yet a circumstance to be mentioned which is perhaps of some interest in connection with this species. Quenstedt in his "Petrefactenkunde Deutschlands, Brachiopoden," draws the attention of men of science to the circumstance that *Prod. semireticulatus*, Mart., is nearly always found with gaping valves, the valves having turned so far on the hinge that the shell became widely open before being imbedded in the rock. Quenstedt considers such a position of the valves impossible if the two had not been united along the hingeline by a ligament. The same position of the valves is the prevailing one in the specimens belonging to the present species as well as to others, and the same suggestion has presented itself to me independently, before I had come on Mr. Quenstedt's observations. Several other points have been adduced already in this work, which tend to make the same supposition at least probable to a certain extent.

8. Productus vishnu, Waagen, n. sp., Pl. LXXI., figs. 2-3.

This is a tolerably large species, with an extremely elevated visceral part, strongly separated wings and an almost entirely smooth frontal part of the ventral valve. The dorsal valve is not known to me.

The ventral valve is extremely inflated, and its curve is very regular, forming nearly an entire spiral in the longitudinal direction. Transversely the shell appears flattened on the wings, then the outline suddenly ascends enormously and forms a highly elevated broad curve, which is strongly impressed in the middle. The apex is pointed, tolerably prominent, and distinctly overhangs the hingeline. Not very far from the apex a very deep and acutely impressed sinus commences, which extends down to the front. The wings are also in certain specimens limited off from the remainder of the shell by a deep furrow, whilst in others this furrow is absent. The sculpture of the valve consists in the apical region in a very coarse reticulation, in which the concentric folds are predominant over the radial ones, and on the wings only the concentric folds are present. This reticulation extends up to 40 mm. distance from the apex measured along the curve. Where the reticulation stops, the radial folds have become already very weak and indistinct, and

before they reach the front they disappear almost entirely. The shell has thus in certain positions, when the reticulated part is not visible, a certain resemblance to *Prod. horridus*. Over the whole surface of the valve very strong erect spines are quite irregularly distributed; their number is, however, never very large.

In this species better than in any other species of *Productus* the different structure of the different shell-layers can be observed. The outer layer is quite smooth and compact, covered with a great many fine striæ of growth; the inner layer, on the contrary, is thickly strewn with fine elongated punctures. I have given on Pl. LXXI enlarged figures of both layers.

The dorsal valve as well as the interior characters of the species are entirely unknown to me.

The measurements of a specimen from Chidru are as follow:—

Length of the shell in a straight line	55 mm.
„ „ „ along the curve	107 „
Length of the hingeline	60 „
Thickness of the ventral valve	39 „

Locality and geological position.—This is an extremely rare species, and there have been detected up to the present not more than two specimens of it. Both come from the middle division of the Productus-limestone. One of them was found by Mr. Wynne at Khund, the other by myself at Chidru.

Remarks.—The species which is most nearly related to the one under consideration is *Productus indicus*. I have separated the two specimens on which the present species is founded from *Prod. indicus* on account of the enormously elevated visceral part of the shell and the peculiar sculpture these specimens exhibit.

This is the most peculiar form of all the *Semireticulati*, and it is very strange to observe how it approaches the *Prod. horridus* in its sculpture, yet being so widely separated from that species by its coarsely reticulated apical part. This form might perhaps be considered as the most strongly specialised of all the *Semireticulati*.

e. Group of *PRODUCTUS PORTLOCKIANUS*, Norw. & Pratt.

9. Productus gratiosus, Waagen, n. sp., Pl. LXXII, figs. 3-7.

The dimensions of this species are always very moderate, and specimens as large as the one figured in Pl. LXXII, fig. 3, are great exceptions. As to outline and sculpture, the present species is most elegant, and it reproduces on a small scale, but with much more neatness, the form of *Prod. semireticulatus*.

The ventral valve is rather strongly inflated, but its curve is not very equal in the longitudinal direction. It appears flattened in the apical region as far as the reticulation extends, then a slight geniculation occurs, and only after this does the valve show a regular curve down to the anterior margin. Transversely the curve

is regular, strongly impressed in the middle. The apex is strongly pointed, not much bent over, and barely at all overhangs the hingeline. This latter is not very long, but yet occupying the greatest breadth of the shell. In consequence of this the wings are very small, but distinct and pointed. Very near the apex, nearly at its point, a deep rather narrow sinus commences, and extends down to the front line. The sculpture is very characteristic. In the vicinity of the apex a very distinct and fine reticulation exists, which is so very fine and neat that it resembles the very neat reticulation often exhibited on the shell-surface of recent species of *Nassa* or the like. This reticulation extends from the apex, for about 12 mm. measured along the curve. After this only the radial ribs remain; they are very high, and separated from each other by very narrow deep furrows. Sometimes one or the other of the ribs bifurcates; more often, however, the ribs converge from both sides towards the depth of the median sinus, so that often several of them become eliminated towards the anterior border. The ribs are mostly not all of the same strength, those situated on the top of the two lobes or folds produced by the impression of the median sinus being generally thicker and more prominent. On all the radial ribs a great number of very fine erect spines are distributed. They are as numerous as in *Prod. muricatus*, Phill., but are at the same time so fine that even the place of insertion of the spines can barely be observed, if the surface of the shell is slightly weathered. This is the reason why on the figures Pl. LXXII comparatively so few spines are represented.

The dorsal valve is extremely characteristic in this species. It is on the whole very regularly concave and not geniculated. Its concavity is very strong and interrupted in the middle by a narrow very strongly prominent median fold. The visceral part of the valve is distinctly and very finely reticulated; beyond this only radial ribs remain. These are much narrower and sharper than on the other valve, and are separated from each other by broad rounded furrows. Their distribution is very peculiar: as soon as they pass beyond the reticulated part they diverge fan-like on each side of the median fold, so that the median ones converge towards the top of this fold, while the marginal ones extend towards the wings. A consequence of this distribution is that the ribs very often bifurcate regularly. On the wings themselves only the concentric folds occur. The spines of the other valve are represented on this one by grooves. Erect spines do not exist on the dorsal valve.

The interior characters of this species are not known to me.

The dimensions of the largest specimen are approximately as follow:—

Length of the shell in a straight line	27 mm.
„ „ „ along the curve	55 „
Length of the hingeline	26 „
Thickness of the ventral valve	17 „
Distance of the two valves from each other	12 „

Locality and geological position.—This species is most numerously represented in the middle division of the Productus-limestone. It commences already in the

lowest beds of this division, and has been collected in this position by myself at Chidru. The higher beds of the middle division have furnished very numerous specimens at certain localities as at Morah, where Mr. Wynne collected 25 specimens. I myself found the species in the same geological position west of Katwáhi (1 sp.), at Virgal (coral-beds 1 sp.), on the road from Vurcha to Uchâli (1 sp.), and at Khura, where I observed the species as well in the topmost beds of the middle division (4 sp.), as in the lower beds of the upper division of the Productus-limestone (2 sp.).

The higher beds of the upper division have furnished to me specimens in the *Cephalopoda*-bed at Jabi (7 sp.) and in the same bed at Chidru (1 sp.).

Remarks.—This is one of the most elegant species occurring in the Salt-range. It is no doubt related to a certain extent to *Prod. semireticulatus*, Mart., but the constantly smaller size and the much more prominent radial ribs make a distinction not very difficult. Beyrich figures a variety of *Prod. semireticulatus* from the island of Timor, which most nearly approaches the Indian shell here under consideration; the ribs seem, however, also in this form less elevated. Another European shell to which the present species can be compared is *Prod. griffithianus*, Kon. It has a similarly fine and elegant reticulation in the vicinity of the beak, but it remains always smaller, flatter, and has a geniculated dorsal as well as ventral valve.

I have approached the Indian shell to *Prod. portlockianus*, Norw. and Pratt., on account of the very sharp and deep sinus and the mediocre size exhibited by that American shell, and probably the shell figured by Beyrich from Timor under the name of *Prod. semireticulatus* must also be approached to that species. These three forms, the American and the two eastern ones, seem to constitute a group characteristic of upper-carboniferous and permian beds.

These forms, chiefly the Indian one, seem to be rather nearly related to *Prod. muricatus* of Phillips, on account of the great number of fine erect spines, which are distributed on the radial ribs of the Indian shell. Phillips' species can, however, be distinguished as far as can be judged from the figures, no specimens of the species being available to me, by the absence of a median sinus and of the reticulation in the vicinity of the apex. On account of these characters, however, the true *Prod. muricatus* seems to be referable to a quite different division of the genus, and the transitional forms between that species and *Prod. costatus*, Sow., that have been observed by Mr. Davidson must be attributed very likely only to hybridity.

III.—Section SPINOSI.

f. Group of *PRODUCTUS MURICATUS*, Phillips.

10. Productus asperulus, Waagen, n. sp., Pl. LXXIX, figs. 3-6.

The general outline of this species is roundish or transversely oval. The shell is always of a very moderate size; the ventral valve never inflated, and the dorsal

one only flatly concave. Both valves are covered with a comparatively coarse radial ribbing, on which very numerous erect spines are placed.

The ventral valve is flat, never much vaulted. Its curve is rather regular in the longitudinal direction, only the apex being slightly more strongly bent. In the transverse direction the curve is yet more regular, only in the middle a slight depression takes place in some specimens. The hingeline is short, always shorter than the greatest breadth of the shell. The apex is pointed, but little bent over, barely prominent, and not at all overhanging the hingeline. At a certain distance from the apex in some specimens a slight median depression is developed, which extends down to the front. The sculpture of the valve consists in a coarse radial striation or ribbing, which is rather irregular, inasmuch as the ribs are often dichotomous towards the front or else sometimes also two are united into one. On these ribs very numerous erect spines are irregularly distributed. Generally a spine is developed where a rib splits up in two, but also otherwise the ribs are provided with spines. The ribs are generally slightly swollen where a spine rests on them. Also along the hingeline a very distinct row of spines extends.

The dorsal valve is flatly concave, with little developed flattened wings, on which only a slight concentric folding is observable. The sculpture of the valve consists of coarse dichotomous radiating striæ, on which sometimes slight traces of spines can be observed. Between the ribs at some places deep grooves are to be found, which correspond to some of the erect spines of the other valve. The ribs of this valve are very distinctly flattened on the top.

Of the interior characters of this species nothing but the cardinal process is known to me, which is rather small and trifid, supported by two lateral ridges and a median septum. This latter becomes bifid not far from the cardinal process.

The measurements of a specimen from Jabi are approximately the following :—

Length of the shell in a straight line	27 mm.
„ „ „ along the curve	39 „
Greatest breadth of the shell	32 „
Length of the hingeline	22 „
Thickness of the ventral valve	11 „
Distance of the two valves from each other	6 „

Locality and geological position.—The species is on the whole rather rare in the Salt-range. It has been chiefly found by me in the *Cephalopoda*-bed of the upper Productus-limestone at Jabi, where I obtained six specimens. It is much less frequent in the *Cephalopoda*-bed at Chidru, only two tolerably well preseved specimens having been collected by me.

The species is, however, not restricted to the upper division only, two fragments of the species having also been found by me in the middle division at Káfirkot.

Remarks.—The shells under consideration have puzzled me a great deal, as it appeared very difficult to decide in what relations to other forms these specimens might stand. On a first glance the species is not dissimilar to *Prod. cora*, Orb., but the radial ribs are much coarser, the spines much more numerous, and

the concentric folds on the wings are absent. Also *Prod. carbonarius*, Kon., or *Prod. koninckianus*, Keys, as well as *Prod. cancrini*, Keys, all three forming one group, are similar to a certain extent to these shells; and I was long time in doubt whether I should not consider *Prod. asperulus* as forming part of this group of forms. Nevertheless I could not satisfy myself in this direction. In those species the radial ribbing is much finer and the spines cause an elongated swelling of the ribs, which is not observable in the Indian shells. Thus it appeared impossible to affiliate this form to the species mentioned above, and there remained at last only *Productus muricatus*, Phill., to which the new species could be compared.

Phillips' species was but very imperfectly and inaccurately known before the publication of Mr. Davidson's admirable drawings of it, but from these drawings it appears that *Prod. muricatus* does not belong to the *Semireticulati*, but rather to the "*Spinosi*," as there seems to be no trace of a reticulation in the vicinity of the apex. In the specimen figured by Davidson (Mon. Brit. Carb. Brach., pl. XXXII, fig. 13) the radial ribs are as fine as in the Indian specimens, and in the magnified figure the ribbing shows absolutely the same irregularities which appear in my specimens. Also the character of the spines is identical in both. I thus came to consider the *Prod. asperulus* as very nearly related to *Prod. muricatus*, and distinct from Phillips' species chiefly only by its comparatively flat ventral valve and little projecting visceral region.

IV.—Section: FIMBRIATI.

g.—Group of *PRODUCTUS HUMBOLDTI*, Orb.

2. Productus humboldti, Orbigny, Pl. LXXVI. figs. 1-3.

1842. *Productus humboldti*, Orbigny: Voyage dans l'Amérique Méridionale, Tome III, 4me Partie, p. 54, Pl. V, figs. 4-7.
1846. *Productus humboldti*, (Orb.) Keyserling: Petshoraland, p. 201, Pl. IV, fig. 3.
1847. *Productus humboldti*, (Orb.) Koninck: Monogr. d. gen. Prod. et Chon. p. 114, Pl. XII, fig. 2 a, b, c.
1862. *Productus humboldti*, (Orb.) Möller: Mining Journal of St. Petersburg, p. ?
1878. *Productus humboldti*, (Orb.) Abich: Bergkalk-Fauna von Djoulfa, p. 35, Pl. V, fig. 2.
1879. *Strophalosia horrescens*, (Vern.) Möller: Neu. Jahrb. f. Min., p. 233-234.

The species is generally of a moderate size, and only rarely are specimens met with exhibiting the size of D'Orbigny's original.

The general outline is always more or less transversely oval, and the ventral valve, which is generally not very strongly inflated, bears in the middle a sinus of somewhat variable depth. The whole surface is covered with a great number of fine bent-up spines.

The ventral valve is mostly only moderately inflated, sometimes even rather flat. Its curve is tolerably regular in both directions. The apex is thin, pointed, not much prominent, and strongly bent over. It overhangs slightly the hingeline. This latter is straight, always shorter than the greatest breadth of the shell, and in

nearly all the specimens at my disposal provided with a narrow area. At both ends of the hingeline small rounded wings are developed, in which the hingeline joins the lateral margins of the valve under an obtuse angle. Not far from the apex a mostly rather shallow sinus commences, which extends often not quite down to the anterior margin. The whole surface is covered with very numerous small elongated tubercles, which at their lower extremity bear a thin erect spine. These tubercles are much finer and more numerous in the vicinity of the anterior and lateral margins of the valve, and this more finely tuberculated space forms a distinct zone all round these margins. This finely taberculated zone is a peculiarity characteristic of all the species belonging to the group of *Productus humboldti*. The tubercles are arranged irregularly in quincunx.

The dorsal valve is very flat, barely at all concave. In the vicinity of the apex two diverging folds exist, which separate the wings from the visceral part of the valve. A median fold, corresponding to the sinus of the other valve, can barely be distinguished. The sculpture of the valve consists of very numerous little grooves arranged in quincunx, between which very fine little spines are distributed.

The interior characters of the species are not known to me.

The measurements of a specimen from Vurcha are approximately the following:—

Length of the shell in a straight line	30 mm.
„ „ „ along the curve	50 „
Greatest breadth of the shell	35 „
Length of the hingeline	24 „
Thickness of the ventral valve	15 „
Distance of the two valves from each other	12 „

Locality and geological position.—*Productus humboldti* is very rare in the Salt-range; there have been found up to the present only five specimens, which all come from the middle division of the Productus-limestone. There have been collected two specimens by myself in the section at Khura in the upper region of the middle division, and two other specimens in a somewhat lower position at Káfir-kot. Mr. Wynne brought one specimen from the middle division at Vurcha.

Remarks.—I regret very much to say that I must differ somewhat from Mr. Davidson in the interpretation of this species. The shell that has been figured by him from the Salt-range under the name of *Productus humboldti* seems to differ from the true form of the species that has been so excellently figured by Koninck, by its much coarser sculpture and less numerous tubercles, and agrees in this respect much more with the shell that has been described by Abich from Djoulfa under the name of *Prod. scabriculus*. There seems therefore to me a distinction necessary, and I therefore shall describe this coarsely tuberculated shell under the name of *Prod. abichi*.

I thus retain the name of *Productus humboldti* only for the finely tuberculated shells which are very rare in the Salt-range, but which seem to be characteristic of the beds of the coal-measures of South America and of the upper carboniferous lime-

stone of the Ural. The forms approach in all respects very nearly the shell that has been figured by Koninck from Yarbichambi, and the chief difference seems only to consist in a somewhat more elevated visceral part of the American shell. I shall, however, have occasion to demonstrate on the specimens belonging to the species *Prod. abichi* that this character is rather variable and that specimens with and without a moderately elevated visceral part occur in the same species.

The Indian specimens of *Prod. humboldti* are absolutely identical with what has been described by Abich from Djoulfa as belonging to the same species. Also at Djoulfa this species is apparently rare, as Geheimrath Abich possesses only a single specimen from there.

The bed in which this shell was found has been identified by Möller as of permian age, and this has probably also been the reason why Prof. Möller considered Abich's specimen as belonging to *Strophalosia horrescens*, Vern., otherwise I cannot quite well conceive why this should have been done. Abich's specimen has neither a trace of a point of attachment on the ventral valve, nor the trace of an area, and thus it is impossible to consider it as anything else than a *Productus*.

The occurrence of *Prod. humboldti* in the permian beds of Djoulfa is of very great interest, as it shows that the species ascends in single specimens up into the permian formation.

12. Productus abichi, Waagen, n. sp., Pl. LXXIV, figs. 1-7.

1862. *Productus humboldti*, (Orb.) Davidson: Quart. Journ. Geol. Soc. Lond., Vol. XVIII, p. 32, pl. II, fig. 6.
1863. *Productus humboldti*, (Orb., Davids.) Koninck: Foss. paléoz, de l'Inde, p. 39, pl. XII, fig. 6.
1878. *Productus scabricalus*, (Mart.) Abich: Geologische Forschungen in den kaukasischen Ländern, Vol. I, Ueber eine Bergkalk-Fauna von Djoulfa, p. 33, pl. V, fig. 3.
1879. *Strophalosia horrescens*, (Vern.) Möller: Neues Jahrb. f. Min. p. 233-234.

This species is much more common than the preceding one. It has the same transversely oval outline, a moderately inflated ventral valve with a flat sinus in the middle, but the sculpture is different. It consists of rather coarse, very strongly elongated and more or less irregularly arranged tubercles, which bear at their anterior extremity thin somewhat erect spines. The number of these tubercles is much smaller than in the true *Prod. humboldti*.

The ventral valve is not very strongly inflated generally, and only some rare specimens, as the one figured Pl. LXXIV, fig. 7, make an exception to this rule. The curve is generally very regular in the longitudinal direction, less so transversely. In this latter direction the sides appear to ascend rather abruptly, while the valve is rather flattened on top with a median impression for the sinus. The wings are small and barely flattened. The frontline is always impressed as the median sinus of the valve extends down to it; the lateral margins are well rounded and join the hingeline always under an obtuse angle. This latter is straight and always shorter than the greatest breadth of the shell. Mostly there extends a

small area along the hingeline which in some cases attains a breadth of one millimeter, it is then cut out in the middle by a very large sharply defined deltidial fissure. The apex is very strongly bent over, thin, pointed and only very slightly overhanging the hingeline. The median sinus commences in some specimens immediately at the apex, in others only at a certain distance from it. This sinus is mostly rather deep and well developed, and extends down to the frontline. The most characteristic feature of the valve is its sculpture. This is not everywhere and in all specimens absolutely the same. On the greater part of the valve it consists of rather strong elongated tubercles, which are mostly arranged in a rather regular quincunx and bear at their anterior extremity a rather long thin spine, which is but little elevated over the surface of the valve and directed forward. On the wings and towards the lateral and frontal margins the tubercles become much smaller, much more closely packed together, and are no longer elongated but forming roundish pustules. These bear erect spines on the top and are arranged in concentric zones, which are separated from each other by strong imbricating striæ of growth. Otherwise a concentric sculpture is entirely absent in the specimens belonging to this species.

The dorsal valve is nearly quite flat, and only the margins are somewhat bent up. The apex is distinctly excavated, and on both sides of it originate low, broad, diverging folds, which separate the flattened wings from the visceral part of the valve. At a very short distance from the excavated apex a broad, low, median fold is developed extending to the frontal margin. The hingeline is generally without an area in this valve. The sculpture of the valve is very characteristic. It consists of a great number of low rounded little pits, which are arranged very regularly in quincunx, and between these pits an equal number of very fine erect spines are placed.

The interior characters of the species are well known to me. In the ventral valve the lower margin of the area is always thickly set with a row of fine short spines, comb-like. The shell is always extremely thin and fragile, and thus the attachments of the muscles are but very little impressed and rather indistinct. The adductors form two elongated impressions on both sides of the middle line not far from the apex, but I cannot distinguish a dendritic sculpture on them. The divaricators are much larger, extending a good deal further down than the adductors, and are radially striated. They are situated outside and below the adductors. The whole inside of the valve is covered with alternating grooves, corresponding to the tubercles of the outer side, but there are no open pores in which the hollow spines would terminate. A more or less broad zone along the margins of the valve is thickly covered by small spiny tubercles.

In the dorsal valve the cardinal process is very long and thin, trifid at its upper extremity. At its base it bears two prominent tubercles. Laterally it is supported by two stout ridges, which extend interiorly along the hinge-margin, and on its lower side it is prolonged into a long, thin, high, blade-like median septum. On both sides of the septum, about in the middle of the valve, two prominent elongated

tubercles are situated, above which the muscular impressions are placed; these are dendritic. The two pairs of adductors can barely be distinguished. The same is the case with the brachial ridges, which are so faint that it is barely possible to see them. I cannot positively assert that they have been rightly represented by the draftsman; their size is, however, correct in the drawing. At the place where the shell begins to be bent up, and lower down, are situated a great number of long thin thorns, directed forward. Otherwise the whole internal surface of the valve is covered with a not very fine granulation.

There are some specimens in the Salt-range collection which I suppose to have preserved their original colour. While all the other specimens in the same beds are of a greyish yellow, these are of a dark violet or reddish brown. I have attempted to represent these colours on the plate.

The measurements of the specimens belonging to this species are rather uniform. The largest specimen known to me, from the *Cephalopoda*-bed at Jabi, exhibits the following dimensions:—

Length of the shell in a straight line	34 mm.
„ „ „ dorsal valve in a stright line	27 „
„ „ „ ventral valve along the curve	65 „
Greatest breadth of the shell	42 „
Length of the hingeline	32 „
Thickness of the ventral valve	21 „
Distance of the two valves from each other	17 „

Locality and geological position.—The species is rather common in the Productus-limestone of the Salt-range. It occurs there in the middle division as well as in the upper division, but has not been detected up to the present in the lower division.

In the middle division it has been found at Khund (1 sp.), in the section at Khura (2 sp.), at Morah (10 sp.), on the road between Vurcha and Uchâli (7 sp.), at Musakheyl (2 sp.), at Chidru (4 sp.), and at Kâfirkot (10 sp.).

Out of the upper division it came from the following localities: From the section at Khura (1 sp.), and west of the same village (6 sp.), from the *Cephalopoda*-bed at Jabi (11 sp.), and from the same bed at Chidru (7 sp.).

Remarks.—The present species has been long known to science, but either it has been united with *Prod. humboldti*, or it has otherwise been wrongly identified. It must be admitted that it can scarcely be considered as directly wrong that one should consider the shells here under consideration to form one and the same species with *Productus humboldti*, as it is solely a matter of taste whether the differences be admitted or not as sufficient for the distinction of two separate species. To me it appeared more practical to distinguish the frequent form of the Salt-range, which deviates by its coarser tuberculation and by the more elongated form of the tubercles from the true *Prod. humboldti*, under a separate name, in order to let it immediately appear most distinctly that forms exactly agreeing with the true *Prod. humboldti* are very rare, while that species is for the most part replaced here by another form,

which, though not very different, yet can always be distinguished from the typical shape.

By Geheimrath Abich this species has been identified with *Prod. scabriculus*, Mart., but it is distinct from Martin's species by the absence of any radial striation to support the tubercles.

Prof. Möller's identification of the present species with *Strophalosia horrescens*, Vern. is quite as wrong. It cannot be denied that the whole group of *Prod. humboldti* bears a certain resemblance to that *Strophalosia*, but even if in some exceptional specimens the area is comparatively not so very small, yet there is never observable a point of attachment on the ventral valve, nor are there any traces of hingeteeth developed. Also in Abich's specimen from Armenia the area does not exceed the height of one millimeter, dimensions which very often occur in true species of *Productus*. Otherwise the specimens from the Salt-range and that from Armenia are extremely similar, only the arrangement of the tubercles is not so regularly in quincunx in Abich's specimen as in the greater number of specimens from the Salt-range, but there are also in the latter place specimens which have their tubercles quite as irregularly arranged. I think there can be no doubt about the Salt-range form being absolutely identical with that from the permian beds of Armenia.

Of other species *Prod. nebrascensis*, Owen, must still be compared. This species also has been mistaken by Geinitz for *Stroph. horrescens*—a further proof how similar the whole group of *Prod. humboldti* is to that permian species. *Prod. nebrascensis* is very easily distinguishable from *Prod. abichi* by the two different sets of spines it possesses, and by the more distinct radial striation, interrupted from distance to distance by concentric folds.

13. PRODUCTUS SERIALIS, Waagen, n. sp., Pl. LXXIV, fig. 8; Pl. LXXV, figs. 1, 2.

It is with much doubt that I introduce this species; it cannot however be denied that the specimens which I describe under the name show certain peculiarities by which they deviate from other forms.

The shells are on the whole very similar to *Prod. abichi*, but distinct by a well-developed concentric folding, in a more or less close relation to the spines distributed on the surface of the ventral valve. It is even not improbable that I include two species under this name, each represented by a single specimen, of which the one bears very coarse, the other very fine spines. The materials are, however, not sufficient to make the distinction complete.

In both specimens the ventral valve is not very strongly vaulted, and its curve is tolerably equal in both directions. The apex is pointed, not very prominent, well bent over and barely overhanging the hingeline. This latter is always considerably shorter than the greatest breadth of the shell, and in one of the specimens (Pl. LXXIV, fig. 8) is provided with an area of one millimeter in breadth. The wings are small and barely flattened. The valve possesses a rather deep median sinus,

which commences at the apex itself in the specimen figured Pl. LXXIV, fig. 8, while in the other specimen its commencement is at a certain distance from the apex. The sculpture is different in the two specimens. In the one (Pl. LXXIV, fig. 8) it consists of strong very much elongated tubercles bearing at their extremities spines which are directed forward; between these, smaller tubercles are irregularly distributed having erect spines. In the other specimen (Pl. LXXV, fig. 2) the elongated tubercles are much thinner, and the smaller ones with erect spines much less frequent. In both specimens the tubercles become smaller and more numerous towards the margin. Between these tubercles in both specimens eight strong concentric folds extend, on the margins of which the greater numbers of the spines are situated.

The dorsal valve is nearly quite flat, and only the margins are somewhat bent up. It bears a sculpture which is coarse in the one and fine in the other specimen, but otherwise the characters of the sculpture are very similar. It consists of very numerous little grooves, between which a great number of fine, more or less erect, spines are situated. There is moreover no very distinct concentric folding of the valve observable.

The interior of a dorsal valve, which I suppose to belong to this species, is figured in Pl. LXXV, fig. 1. The cardinal process is very large in this valve and deeply trifid. It bears a rounded boss at its base and is laterally supported by two very strong and high horizontal ridges, which extend for the whole length of the hingeline. Towards the interior of the valve the cardinal process is continued into a high blade-like median septum, which extends as far as the visceral part of the valve. On both sides of the septum, not far from the base of the cardinal process, the muscular impressions are very distinctly visible. They are comparatively small, dendritic, and the two pairs can well be distinguished. The brachial ridges are well developed, and are composed of an obliquely descending lamella which suddenly bends round forming a hook-shaped curve extending down to the very edge of the visceral part of the valve. This latter is very distinctly marked off from the trail by an angular ridge which is thickly set with long strong spines. Also the trail is covered by many spiny tubercles, while on the remainder of the interior surface of the valve only a fine granulation is observable.

Of the interior of the ventral valve nothing is known to me.

One of the specimens in my possession shows the same colour as those specimens of *Prod. abichi*, and which I supposed in them to be the original colouring.

The dimensions of the two specimens, both from Jabi, are as follow :—

	I.	II.
Length of the shell in a straight line	33 mm.	29 mm.
„ „ along the curve	60 „	50 „
Length of the dorsal valve	29 „	26 „
Greatest breadth of the shell	41 „	35 „
Length of the hingeline	30 „	26 „
Thickness of the ventral valve	19 „	15 „
Distance of the two valves from each other	15 „	12 „

Locality and geological position.—There have altogether been detected up to the present only the three specimens that have been figured. All three were collected by myself at Jabi in the *Cephalopda*-bed of the upper division of the Productus-limestone.

Remarks.—The present species can on a first glance only with difficulty be distinguished from *Productus abichi*, from which it differs by its concentric sculpture.

Another species, to which the present one is very nearly related, is *Prod. nebrascensis*, Owen. Specimens of the species that I have obtained from Illinois are however much less transversely oval, the hingeline is comparatively long, and the sculpture is quite different. The spines, as has been rightly observed by Meek, consist of two different kinds, which are approximately alternating. The thicker ones are erect, the thinner ones bent forward at a short distance from the surface of the valve. Besides this the spines are situated on a kind of radial striation, not dissimilar to that existing in *Prod. scabriculus*, Mart. These characters of the sculpture do not at all agree with those of our Indian shells, in which erect spines occur only exceptionally, and a radial striation is entirely absent. Only the concentric folds are common to both species.

14. Productus cylindricus, Waagen, n. sp., Pl. LXXV, figs. 3, 4.

The specimens composing this species attain not quite middle size. They are characterised by vertical sides, parallel lateral margins and a very much produced anterior part of the shell, whereby the general outline becomes nearly rectangular. The sculpture consists of a rather fine granulation, which changes into a radial striation on the produced part.

The ventral valve is very strongly but rather irregularly vaulted. In the longitudinal direction the spiral part appears very strongly curved, whilst the anterior part is considerably flattened. In the transverse direction the outline ascends vertically from the lateral margin, and forms a flattened curve, which is somewhat impressed in the middle, on the median part of the valve. The apex is attenuated, pointed, strongly bent over and not much prominent; it barely overhangs the hingeline. This latter is short, equal to or shorter than the greatest breadth of the shell. In none of the few specimens at my disposal is it provided with an area. There are no wings at the ends of the hingeline. The valve is provided with a not very deep median sinus which commences at a short distance from the apex, and disappears again before it has quite reached the anterior margin of the valve, which, in consequence, has a rounded, not indented, outline. The sculpture of the valve is of two different kinds. On the visceral part of the valve, up to a distance of about 35 mm. from the apex, measured along the curve, the sculpture consists of numerous, fine, elongated, sharply-pointed tubercles, which are arranged irregularly in quincunx, and are placed on some coarse, not strongly developed concentric folds. The tubercles have evidently once served for the support of spines, but these

are not preserved on any of the specimens at my disposal. When the shell grows larger, tubercles and spines disappear altogether, and are replaced by a fine radial striation which becomes more and more coarse as it approaches the interior margin, so that this margin at last is ornamented only by a few coarse folds.

The dorsal valve is flat in the visceral region, with bent-up margins. The apex is most strongly excavated, and from both sides of it there extend two low strongly diverging folds towards the lateral margins of the valve. At a certain distance from the apex a low broad median fold is developed, which disappears again further on. The sculpture consists of a great number of little grooves, arranged about in quincunx, between which very numerous, extremely fine, hair-like erect spines are placed.

The interior characters of the species are not known to me.

The dimensions of a rather small but very complete specimen from Chidru are as follow :—

Length of the shell in a straight line	33 mm.
„ „ „ along the curve	62 „
„ „ dorsal valve	22 „
Greatest breadth of the shell	26 „
Length of the hingeline	21 „
Thickness of the ventral valve	19 „
Distance of the two valves from each other	15 „

Large specimens are about 37 mm. in length and 29 mm. in breadth, but these are the largest known to me.

Locality and geological position.—This is a very rare species, and has been found by me only in the *Cephalopoda*-bed of the upper Productus-limestone. I collected the species in this bed both at Jabi (4 specimens) and at Chidru (1 sp). Another specimen has been found by Mr. Wynne at Vurcha, but the bed it came from is not known.

Remarks.—The form most nearly related to the present species is beyond doubt *Productus humboldti*, Orb. It has the same fine granulation, but there are wings developed, the general outline is not rectangular, the sides not vertical, and on the margin of the ventral valve, which is anteriorly not produced, there is a granulation instead of a radial striation, so that *Productus humboldti* can most easily be distinguished, and the present form must be separated from it under a different name.

Productus cylindricus bears, however, yet a great resemblance to other shells which have mostly been described under the name of *Strophalosia horrescens*, Vern., var. *elongata*, Barbot de Marny, or var. *prysmatica*, Golovkinsky. It is true that these shells have a well distinguishable area, but as we know that an area occurs also not very rarely in species of *Productus*, it would be highly desirable to learn some more particulars about the internal structure of these shells, in order to make sure whether they ought to be considered really as a *Strophalosia* or else as a *Productus*. If the latter be the case, the possibility would not be excluded that these shells were identical with our *Productus cylindricus*.

h.—? Group of *PRODUCTUS PUSTULOSUS*, Phill.

15. Productus bhalensis, Waagen, n. sp., Pl. LXXV, fig. 5.

It is only upon a single specimen that I can found this species, but the occurrence of this specimen in the *Fusulina*-sandstone of Bhal is of too great interest to pass it over in silence.

The general outline is somewhat triangular, the hingeline being very short and the front comparatively very broad. The ventral valve is not very much vaulted, but the curve is very regular in both directions. The apex is rounded, not pointed, barely at all prominent and little incurved. It is not quite regularly developed but somewhat twisted to one side. The hingeline is not quite straight, but at both ends a little bent up. An area seems not to exist. The wings are very small but flattened, and their outline forms an obtuse angle. The valve presents in the middle a kind of flattening or very shallow median sinus, which commences at a short distance from the apex and extends down to the front. On the specimen which I have for description the shell is only partly preserved, the greater part of it being an internal cast only. The substance of the shell is, however, so very thin that the sculpture of the cast is identical with that of the shell. This sculpture consists in numerous, slightly elongated tubercles, which apparently have borne very thin spines. The tubercles are arranged irregularly in quincunx, and the whole surface is sub-divided in broad concentric zones by a few concentric folds extending parallel to the shell margins.

Neither the dorsal valve nor the interior characters of the species are known to me.

The measurements of the only existing specimen are as follow :—

Length of the shell in a straight line	48 mm.
„ „ „ along the curve	75 „
Greatest breadth of the shell	50 „
Length of the hingeline	22 „
Thickness of the ventral valve	26 „

Locality and geological position.—The only specimen of this species that has been detected up to the present was found by myself at Bhal in the lower division of the Productus-limestone, contained in a greyish-yellow sandstone filled with numerous beautifully preserved specimens of *Fusulinæ*.

Remarks.—It is with very great doubt that I introduce this species. If it is really a *Productus*, it is most certainly different from all the forms hitherto described. It must then be placed in the vicinity of *Productus pustulosus*, Phill., on account of the character and distribution of its tubercles, but is easily distinguishable from that species by its triangular shape and extremely short hingeline. I must, however, doubt to a certain extent whether this shell is in reality a *Productus*. The bending and twisting of its apex to one side gives a certain irregularity to the form, which recalls somewhat the shape of *Strophalosia*, though I cannot detect

a place of attachment nor an area in the ventral valve. But if this shell be really a *Strophalosia*, a question which can only be solved when more extensive materials will be procurable, then it is apparently very nearly related to *Strop. horrescens*, Vern., and might even prove identical with that species.

i.—*ISOLATED SPECIES.*

16. Productus purdoni, Davidson, Pl. LXXIII, figs. 1-3.

1862. *Productus purdoni*, Davidson: Quart. Jour. Geol. Soc. Lond., Vol. XVIII, p. 31, pl. II, fig. 5.
1863. *Productus purdoni* (Dav.) Koninck: Foss. paléoz. de l'Inde, p. 38, pl. XII, fig. 5.

This is one of the most beautiful species of the Salt-range, but at the same time rather rare.

It is well characterised by the little-inflated ventral valve, its extremely short hingeline, and its sculpture, which consists of extremely numerous fine spines. The general outline is nearly always longer than broad, only in young specimens the reverse is sometimes the case, and the greatest breadth of the shell is always situated in the lower third on its length. The margins are always well rounded, and the front-line is mostly, but not always, indented.

The ventral valve is moderately inflated, but its curve is not regular. In the longitudinal direction the apex is strongly bent and even rolled in, but soon the curve becomes less strong and towards the front the valve appears considerably flattened. In the transverse direction the lateral parts of the valve ascend tolerably strongly, then the shell suddenly bends round to the flattened and slightly impressed middle part. The apex is pointed, very little prominent, not at all overhanging the hingeline. This latter is very short, and in most specimens not quite straight but arched. At both ends it projects a little and causes the formation of very small slightly flattened wings. At a more or less small distance from the apex a median sinus commences which is always broad and often very deep; it extends in all the specimens, with a single exception, to the front of the valve. The sculpture consists of numerous fine elongated tubercles, which are finer and more numerous towards the margins than on the visceral part of the valve. They are mostly arranged very regularly in quincunx, so that the shell appears as if covered with a cross-lineation. The tubercles have served for the support of very thin hair-like tubular spines, which are, however, only very rarely preserved. If the shell is somewhat deteriorated by weathering, chiefly in the vicinity of the margins or on the small wings, the holes which pierce the tubercles are enlarged, and then the shell surface resembles exactly that of *Eichwaldia*, a very fine reticulation being produced. There are on the visceral part of the valve about 6 tubercles within the space of 5 mm., but on the margins I count not less than 10 tubercles within the same space. In one specimen an indistinct radial plication is added to this tuberculation, commencing about midway of the valve and extending down to the margins, the different folds being of very unequal strength.

The dorsal valve is rather flat with a slightly vaulted apical region, which is separated from the wings by two diverging furrows. From this slightly raised apical region a strong and broad median fold takes its origin, and reaches down to the front. On both sides of this fold two excavated roundish parts of the valve are situated. The margins of the valve are more or less strongly bent up, giving to the whole valve a concave appearance. The sculpture consists of a great number of small shallow grooves arranged in quincunx, between which a yet finer granulation is observable, the bases of very fine hair-like spines.

The interior characters of the species are not known to me, except that a comparatively small cardinal process and a very long and strong median septum has been observed in the dorsal valve.

The dimensions of a rather large specimen from Chidru are as follow:—

Length of the shell in a straight line	73 mm.
„ „ „ along the curve	114 „
„ „ „ dorsal valve	62 „
Greatest breadth of the shell	60 „
Length of the hingeline	35 „
Thickness of the ventral valve	31 „
Distance of the two valves from each other	30 „

Locality and geological position.—The species is not very common in the Salt-range, and occurs chiefly in the upper division of the Productus-limestone.

The geologically oldest specimen was found by Mr. Wynne at Kálabágh in grey limestone together with several other fossils which indicate that the bed from which this specimen came was on the limit between the middle and upper divisions of the Productus-limestone.

In the upper division the species has been found by me in the section at Khura (1 sp.), in the section near Kufri (1 sp.), and at Chidru (4 sp.); Dr. Oldham found it at Musakheyl (not silicified, but in a yellowish-grey sandstone, characteristic of the upper division (1 sp.), and Mr. Wynne found the species trans-Indus at Bilot.

The geologically youngest specimen I found myself at Virgal (bed No. I of the section) in the grey sandstones forming the topmost bed of the upper division of the Productus-limestone, immediately below the Ceratite beds. This is the only species of *Productus* that has been found in these sandstones.

Remarks.—The present species is very peculiar in its sculpture and shape, and though to a certain extent it recalls the forms more or less allied to *Productus humboldti*, yet I should not like to directly affiliate it to that group of forms. The hingeline is much shorter and mostly arched, the general outline much more elongated, and the form and arrangement of the tubercles is so peculiar that I must consider the species here under consideration as an isolated form, the relations of which cannot exactly be made out for the present.

The species has not yet been detected in any other part of the world, except in the Himalaya at the Niti Pass, whence it has been described by Salter. The occurrence of this species at that locality indicates with great probability the exist-

ence there of beds of the age of the upper division of the Productus-limestone of the Salt-range, while generally the carboniferous beds of the Himalaya appear to be geologically older.

V.—Section: HORRIDI.

k.—Group of *PRODUCTUS GEINITZIANUS*, Kon.

17. Productus opuntia, Waagen, n. sp., Pl. LXXIX, figs. 1—2.

This species shows always very small dimensions, and resembles in this respect *Productus spinulosus*, Sow. Its general outline is somewhat squarish, the wings very small, the apical part extremely strongly elevated, and the surface covered with many little spines.

The ventral valve is very strongly inflated, and its curve is very regular in both directions. The apex is well pointed, strongly enrolled, in its median part very highly elevated over the hingeline and strongly overhanging it. The hingeline is comparatively long and always occupies the greatest breadth of the shell. At both ends of it small rectangular wings are developed which are but little flattened. A median sinus is never present, only in some specimens a slight flattening of the median part of the valve can be observed. The surface sculpture consists of not very closely set, roundish, pointed tubercles, which are approximately arranged in quincunx. I do not know whether these tubercles have served for the support of spines or not, as in none of the specimens at hand are spines preserved. These tubercles are sometimes in connection with longitudinal ribs, on which they are placed. The latter are chiefly distinct towards the margins of the valve, whilst the tubercles are all of about equal strength. Otherwise only fine cencentric striæ of growth can be observed on the valve.

Neither the dorsal valve nor the interior characters of this species are known to me. Only so much can be stated, that the present species did not possess the characters of the genus *Marginifera*, which will be described next.

The measurements of a very complete, middle-sized specimen from Chidru are as follow:—

Length of the shell in a straight line	13 mm.
„ „ „ along the curve	26 „
Greatest breadth of the shell at the hingeline	14 „
Thickness of the ventral valve	8 „
Distance of the apex from the frontal margin	9 „

The largest specimen known to me is 16 mm. in length and 17 mm. in breadth.

Locality and geological position.—This species seems to be restricted to the *Cephalopoda*-bed of the upper division of the Productus-limestone, and is even there very rare. I have found it myself at Jabi (3 sp.) as well as at Chidru (1 sp.).

Remarks.—For a long time I was inclined to affiliate the present species to *Prod. spinulosus*, Sow., from the European mountain-limestone, as it agreed well with

that species in size. But at least specifically the Indian shell seemed to be different from Sowerby's species by the very strongly elevated median and apical part of the shell, the smaller and less flattened wings, and by the occasional combination of the tubercles with longitudinal ribs. By all these characters, however, the present species approches *Prod. geinitzianus*, Kon., from permian beds of Europe. Thus it seemed on the whole safer to place the shell here under consideration among the allies of Mons. de Koninck's species. It is distinct from that form by its smaller size and constantly absent median sinus, but probably it is only a geographical variation or vicarious species for that permian shell. *Productus wallacianus*, Derby, might also be compared, but the figures are too bad to allow of a closer comparison.

1. Group of PRODUCTUS KIANGSIENSIS, Kays.

18. Productus tumidus, Waagen, n. sp., Pl. LXXX, figs. 1,2, 3.

The size of the present species is always moderate, it never attaining any considerable dimensions. The general outline is transversely oval to squarish or even nearly cubical. The dorsal valve is evenly concave, not geniculated. The sculpture consists of a tolerably fine and not prominent radial plication, which becomes indistinct and irregular towards the margins, and on which not very numerous thin erect spines are irregularly distributed.

The ventral valve is moderately to very strongly inflated, and the curve is always very regular in the logitudinal direction. Transversely the valve appears flattened in the middle, and the lateral parts descend nearly vertically, so that very strongly inflated specimens appear nearly cubical. The wings are generally small, but sometimes bear an expansion which spreads out and descends vertically from the hingeline (Pl. LXXX, fig. 1*c* & 1*e*). The beak is not much incurved, pointed, and not or barely overhanging the hingeline. In strongly inflated specimens the apical region is highly elevated above that line. The sculpture consists of numerous low, broad, rounded radial ribs, which are tolerably regular on the visceral part of the valve, but become irregular as soon as they have passed that region, bending in various directions and splitting up into several finer ribs. A concentric sculpture does not exist, except along the hingeline, where several short folds are observable. There is a not very great number of erected spines irregularly distributed over the surface of the valve. On the apical region they are more numerous than elsewhere, and chiefly two diverging rows are always distinct, extending from the apex on both sides of the visceral part.

The dorsal valve is deeply and regularly concave, and its visceral part is most deeply excavated. The wings are concave and separated from the remainder of the valve by an obtuse ridge. A trace of a median fold is sometimes developed in this valve. The sculpture consists of fine and faint radiating ribs, which are interrupted from time to time by shallow grooves that correspond to the spines of the other valve. Two rows of such grooves are chiefly conspicuous extending

along the ridges that mark off the wings from the remainder of the valve. Of spines not a trace is observable on this valve.

The interior characters of the species are absolutely unknown to me.

The measurements of the largest specimen are as follow:—

Length of the shell in a straight line	30 mm.
„ „ „ along the curve	48 „
Greatest breadth of the shell	30 „
Length of the hingeline	25 „
Thickness of the ventral valve	23 „

Locality and geological position.—The present species is to be met with rather frequently in the middle division of the Productus-limestone, and it occurs much more rarely in the upper division.

In the middle division it has been found on the road between Vurcha and Ucháli (1 sp.), at Morah (2 sp.), at Kálabágh hill (1 sp.), and at Káfirkot (3 sp.).

In the upper divison only the *Cephalopoda*-bed at Jabi has furnished me two specimens.

Remarks.—This species has been for long a great puzzle to me, and even now it is only in a provisorial way that I place it in the section "*Horridi*," its systematic position being still to a certain extent doubtful.

The species to which it is most nearly related is on the one hand *Prod. kiangsiensis*, Kays., and *Prod. chandlessi*, Derby, on the other; but also one of the specimens figured by Koninck (Monogr. du Genre Productus, Pl. X. fig. 2, e. f.) under the name of *Prod. longispinus*, Sow., must be compared. The difficulty of the classification appears already clearly from the systematic position that has been assigned by different writers to these allied species. Prof. Kayser puts his *Prod. kiangsiensis* into the "*Caperati*;" Prof. Derby places his *Prod. chandlessi* on the contrary in Davidson's "*Sublaeves*;" and *Prod. longispinus*, Sow., is counted by Mons. de Koninck among the "*Semireticulati*." I have placed my new species in the "*Horridi*" on account of the great resemblance certain specimens, in which the longitudinal striation becomes indistinct, acquire to the true *Prod. horridus*.

Among all species by far the most nearly related to the present form appears to be *Prod. kiangsiensis*, Kays. This species has been described by Kayser from the upper carboniferous beds of Lo-Ping in China, and is related to the present species by the similarity of the plication of the wings and the arrangement of the spines; it differs from it on the contrary by its smooth ventral valve on which a radial striation only exceptionally occurs, and by its smaller size. A small area occurs occasionally also in the Indian shell.

Productus chandlessi, Derby, from the coal-measures of Itaituba in Brazil, differs from the shell here under consideration by its generally more strongly developed wings, a faint reticulation in the apical region of the ventral valve, a smooth frontal part and a more irregular distribution of the erect spines.

Similar characters distinguish also Mons. de Koninck's *Prod. longispinus* from the present species.

VI.—Section: IRREGULARES.

m.—Group of *PRODUCTUS STRIATUS*, Fischer.

19.—Productus compressus, Waagen, n. sp., Pl. LXXXI, figs. 1, 2.

1862. *Productus striatus*, (Fisch.) Davidson: Quart. Journ. Geol. Soc. Lond., Vol. XVIII, p. 31, pl. I, fig. 18.
1863. *Productus striatus* (Fisch., Davids.) Koninck: Foss. paléoz de l'Inde, p. 37. pl. X, fig. 18.

The general outline of this species is exceedingly variable, sometimes elongated, sometimes roundish, but always the shell is easily recognisable by the many concentric wrinkles it bears and by the wings which are vertically bent down.

The ventral valve is very variable in its inflation, and no constant characters can be indicated on this point. In the longitudinal direction the curve ascends sometimes rather rapidly from the apex, and becomes then more and more flattened towards the front; in other cases it remains rather flat in the apical region and then suddenly bends down to the front. Transversely the curve is somewhat more regular, but also variable, inasmuch as it is more elevated in elongated than in roundish specimens. A strange character consists in the circumstance that the valve is always so strongly compressed in the apical region that in a view from above the lateral margins are concealed below the overhanging lateral parts of the valve. The apex is thin, pointed, and bent over only at its extremity. A hingeline, properly speaking, does not exist. Immediately from the apex the wings, which are rather large and flat, bend vertically down, leaving a comparatively very small triangular space between them, and no room whatever for a straight hingeline. The wings are marked off from the remainder of the shell in some specimens by a flat impression, in others not, but the wings are always easily distinguishable by the spines they bear. There is not a trace of a median flattening or median sinus on this valve. The sculpture consists of very fine radiating lines, which are of equal breadth over the whole extent of the valve, augmenting frequently by intercalation, and bending well down on the lateral portions of the valve so as to reach the margins always at right angles. This longitudinal striation is crossed by numerous tolerably broad rather irregular concentric wrinkles, which are narrowly rounded on top and separated from each other by broad rounded valleys. These wrinkles are restricted to the median part of the valve, and do not extend on the wings. On these latter parts a varying number of irregularly bent long slender spines are situated, which are quite irregularly distributed and extend only a short way along the lateral margins of the valve. On the median part of the valve every trace of a spine is absent.

Of the dorsal valve only fragments are known to me. I only know that it is strongly concave, leaving but very little room between it and the ventral valve, and that it is also covered with a very fine longitudinal striation.

The interior characters of the species are also nearly quite unknown to me. All that I know is, that the dorsal valve bears a very strong and high median septum.

On account of the extreme variability of the outline of the species it appears barely practicable to give exact measurements. All that can be said is, that the species is always of a medium size, and that the dimensions may best be seen from the drawings on Pl. LXXXI.

Locality and geological position.—The species is not very rare in the middle division of the Productus-limestone, where it has been found at Khund (1 sp.), at Morah (3 sp.), at Vurcha (2 sp.), at Katwáhi (1 sp.), in the Chittawán near Ghari (1 sp.), and at Káfirkot (1 sp.).

West of Khura I collected a specimen of the species in the very lowest beds of the upper division of the Productus-limestone.

In the lowest division no specimen has been detected up to the present.

Remarks.—By Mr. Davidson this species has been considered as identical with *Prod. striatus*, Fisch., and I must here expose the reasons why I cannot concur with that learned author on this point. If one compares the true *Prod. striatus*, Fisch., with the present species, one soon finds that the wings, if they are not broken away, are always horizontally spread out; though they be very small, they are never bent down vertically from the hingeline. The concentric wrinkles are few in number and chiefly developed on the wings and lateral parts, disappearing in most cases on the median part of the shell: in *Prod. compressus*, on the contrary, the wrinkles are very numerous and most strongly developed on the median part, whilst they disappear entirely on the wings. These differences seemed to me sufficient to distinguish specifically between *Prod. striatus*, Fisch., and the present species.

The vertically bent down wings, which are not owing to any peculiar preservation of some of these shells, but which regularly occur in all the specimens, produce a very striking appearance in the species. In a lateral view the species thus resembles very much *Prod. ermineus*, Kon., but can easily be distinguished by the absence of a hingeline and the spines on the wings.

A shell which perhaps might be identical with *Prod. compressus* is the one figured by Kayser from upper carboniferous beds of Lo-Ping in China under the name of *Productus cora*, Orb. I would have considered this form as undoubtedly identical with mine, but that the concentric wrinkles appear to be somewhat sharper.

20. Productus mytiloides, Waagen, n. sp., Pl. LXXX, fig. 4.

The general outline of this species is triangular, mytiliform. The ventral valve is but little inflated, the wings small, and the concentric wrinkles are rather faint; a hingeline does not exist.

The ventral valve is but very little arched in the longitudinal direction, but its curve is very regular. Transversely the valve appears much more strongly vaulted,

and chiefly in the apical region its curve forms about a semi-circle; towards the front the valve is only flatly arched. The apex is very strongly pointed, prominent, and but very little incurved. The wings are very small and vertically bent down; they bear a row of spines along their margins, and one or two scattered on their surface. The valve is covered by an extremely fine radial striation, which appears to be much finer than in *Prod. compressus*. While in the latter species there are generally eight to nine striæ within the space of 2 mm., there can generally be counted 12 to 14 striæ within the same space in the present one. The striæ are often very irregularly bent in various directions, and the shell appears often as if injured and again mended. As in other allied species the striæ are curved so as always to meet the margins of the valve at right angles. The spines which have been mentioned as occurring on the wings are the only ones that exist, the remaining surface of the valve being entirely devoid of spines. The concentric wrinkles are neither very numerous nor very distinct; they are, however, strongest on the median part of the valve.

The dorsal valve is very deeply concave from the apex, and this concavity is very regular. It has no wings, and no hingeline, but is narrowly rounded at the apex, the straight lateral margins reaching up to very near the apex. The front is rounded as in the other valve. The sculpture consists of a fine radial striation as in the other valve, and of indistinct irregular concentric wrinkles. Spines are entirely absent on this valve.

As in all the species allied to *Prod. striatus*, Fisch., so in this one the substance of the valves is extremely thin. Of the interior characters of this species nothing is known to me, except that the dorsal valve possessed no prominent median septum.

The measurements of a specimen from Jabi are as follow :—

Length of the shell in a straight line	54 mm.
„ „ „ along the curve	63 „
„ „ dorsal valve	52 „
Entire breadth of the shell	45 „
Thickness of the ventral valve	19 „
Distance of the two valves from each other	5 „

Locality and geological position.—There are altogether only two specimens of this species known to me, one entire and one fragmentary; they were both collected by myself in the *Cephalopoda*-bed of the upper Productus-limestone at Jabi.

Remarks.—This species approaches in its general appearance even more than the preceding one to *Prod. striatus*, Fisch., on account of its feeble concentric wrinkles. Specimens of Fischer's species, in which the wings are broken away, can only be distinguished by their coarser radial striation. In the specimens of *Prod. mytiloides*, however, the wings are not broken; they are well preserved, but not spread out horizontally, on the contrary bent down vertically, and this is a deciding character, which makes a distinction of the Indian shells from the mountain-

limestone species absolutely necessary; as a consequence of this character there is the entire disappearance of a hingeline.

By these vertically bent down wings *Prod. mytiloides* very nearly approaches the *Prod. compressus*, W., described before. It is, however, distinct from that species by its smaller wings, its less sharp and distinctly developed concentric wrinkles and the much finer radial striation.

I have separated the two forms on these grounds in a somewhat provisional way, as the materials which have served for the description of the present species are rather scanty. Nevertheless, the shells from the *Cephalopoda*-bed seemed different from the others, and thus I have come to distinguish the new species; further investigations only will show whether I have been right in doing so or not.

Genus: MARGINIFERA, Waagen, n. gen.

Though species belonging with great probability to the present genus have been described already by several authors, yet no one has drawn particular attention to the rather strange characters by which it differs from *Productus* proper.

It must be admitted that these characters do not make their appearance suddenly, but that they are developed by degrees, so that in the Brachiopod fauna of the mountain-limestone the genus appears to be indicated but not well developed, and only in later geological periods its full development is attained. The observer who has most attentively described the peculiarities in question, and has most conscientiously figured them, is Geheimrath Abich, who has described several species in his monograph of the fossils from Djoulfa on the Araxes. But he deemed these peculiarities not sufficient for the establishment of a new genus.

According to my view, however, they are sufficient for such a purpose. If we consider the family of the *Productidæ* altogether, we find that the generic distinctions are rather difficult within the whole family, and that the limits of the different genera are rather uncertain. Such is the case with *Chonetes*, *Strophalosia*, *Aulosteges*, *&c.*, which all have been considered by many writers only as sub-genera of *Productus*. While however in those cases the distinguishing characters are external as well as internal, in the shells here under consideration the peculiarities are all internal and can be observed only when the shell is partly broken.

The shells which I consider as belonging to the present genus are always rather small, and never attain any considerable dimensions. In their external appearance they are absolutely like *Productus*, so long as the shell is not broken, but as soon as the shell-margin is removed, which very easily happens, the difference comes to light. The cause why the shell-margin so very easily breaks off is a thick prominent shelly ridge, placed vertically on the internal surface of the dorsal valve, and by which the visceral part of that valve is girt. In the ventral valve a similar ridge is developed within the wings only. In this way the visceral part of the shell is perfectly chambered off from the remainder of the shell. These prominent concentric ridges are sometimes finely striated and crenulated, sometimes smooth. The other internal characters are in all the specimens at my disposal

(except in *Marg. typica*, W., where the description will be found) very indistinct, but on the whole they seem to be similar to those of *Productus*.

This strange chambering off of the visceral part by means of proper projecting ridges seems to me perfectly sufficient for the generic distinction of these forms, certainly it is as well worthy of notice as the existence of an area in *Aulosteges* or the like.

In the mountain-limestone this character is not yet well developed in any of the *Productus*-like shells. I have observed indications of such ridges in some specimens of *Prod. longispinus*, Sow.; in which species something of this kind has also been figured by Davidson (Mon. Brit. Carb. Brach., Pl. XXXV, fig. 9), and in *Prod. proboscidens*, Vern., but the development of these ridges is never anything like that occurring in the shells of the Salt-range. The geologically oldest species that probably must be considered as a true *Marginifera* is *Marg. splendens*, Norw. & Pratt., from the coal-measures of Illinois, Missouri and Indiana. I have no specimens of this species for comparison, but as far as can be judged from Norwood's drawings, fig. 5b seems to represent a true *Marginifera*. Among Mr. Trautschold's figures of *Producti* from the upper carboniferous limestone of Moscow, I find no specimens of *Marginifera*. Most numerously the genus seems to be represented in the permian beds of Djoulfa and the Araxes. Mr. Abich has distinguished two species: *Marg. spinosocostata*, Ab. sp. and *Marg. helica*, Ab. sp., which both have been united by Möller with *Productus horridus*. The occurrence of internal ridges, which have been very exactly described and figured by Abich, forbids such an identification.

On the whole it is probable that the genus has taken its origin from *Productus longispinus*, Sow., as all the forms of *Marginifera* appear to be more or less nearly related to Sowerby's species, but that species itself seems to possess the distinguishing characters not yet in sufficiently strong development to be considered as belonging already to the genus *Marginifera*. Only in somewhat more recent geological times, in upper carboniferous beds, the characters of the genus seem to have been quite well developed.

In the Salt-range the genus is rather largely represented, and extends through the whole thickness of the Productus-limestone. Species of the genus are chiefly numerous in the lower division of the formation, where not less than four species occur. The middle division is not so rich in species, but so much the richer in individuals. The same can be said of the upper division where two species occur, one of which is however rare and extends into the topmost beds of the whole formation.

Three of the species form together a well-marked developmental series; these are *Marginifera excavata*, W., a rather common species of the lower Productus-limestone; *Marg. typica*, W., the very common species of the middle and upper divisions; and *Marg. ornata*, W., a rare species of the *Cephalopoda*-bed and of the topmost beds of the upper Productus-limestone. All three are related to a certain extent to *Marg. splendens*, Norw. & Pratt. Two other species, both from the lower Productus-limestone, can be brought into connection with Abich's species of *Marginifera*. One of these is very nearly related to *Marg. spinosocostata*, Ab., and will

bear the name of *Marg. ovalis*, W.; the other agrees to a certain extent with *Marg. helica*, Ab., and will be called *Marg. transversa*, W. At last there remains an isolated species, the relations of which are rather uncertain. It occurs also in the lower Productus-limestone and will receive the name of *Marg. echinata*, W. The species can thus be arranged in the following manner :—

a.—Group of MARGINIFERA SPLENDENS, Norw. & Pratt, sp.
1.—*Marginifera excavata*, W.
2.— „ *typica*, W.
3.— „ *ornata*, W.

b.—Group of MARGINIFERA SPINOSOCOSTATA, Abich, sp.
4.—*Marginifera ovalis*, W.

c.—Group of MARGINIFERA HELICA, Abich, sp.
5.—*Marginifera transversa*, W.

d.—ISOLATED SPECIES.
6.—*Marginifera echinata*, W.

I cannot recognise any of the Salt-range forms in any other locality of the world. Several species described by American authors might be compared to the Salt-range shells, but none is, according to my opinion, identical. It is true the establishing of identity depends to a great extent upon the extension one wishes to give to a species, and if one draws the limits of the single species rather wide, an identity will often be the consequence. Thus all the coal-measure species of America, which probably are for the greater part *Marginifera*, have been united by Mr. Davidson with *Prod. longispinus*, Sow., and yet I must consider *Marg. splendens*, *Prod. wabashensis* and *Prod. capacii* each as a different and well distinguishable species. Also the Indian *Marginifera typica* has been considered by Mr. Davidson as identical with *Prod. longispinus*, Sow. I however should not like to adopt this view. The true *Prod. longispinus*, of which I have some ten specimens for comparison, is different from the Indian form by the entire absence or very insignificant development of internal ridges bordering the visceral portions of the valves. This difference seems to me such an important one that I must consider the Indian shell as belonging to a different genus, and thus this latter cannot possibly be specifically indentical with Sowerby's species. The form with which an identity might perhaps exist is *Marg. splendens*, Norw. and Pratt, and I have in consequence made use of this name for the heading of the group to which my *Marg. typica* belongs.

a.—GROUP OF *MARGINIFERA SPLENDENS*, Norw. & Pratt, sp.

1. MARGINIFERA EXCAVATA, Waagen n. gen. et sp., Pl. LXXVIII, figs., 2, 3.

This species is always of rather small dimensions and of a somewhat transversely oval or even almost transversely rectangular outline. The apical region is

tolerably prominent, the ventral valve inflated and covered by a radial striation bearing a great many long slender spines, which are directed forward. The dorsal valve is concave, devoid of spines, and bears many elongated grooves.

The ventral valve is very strongly inflated and enrolled, forming a not very regular open spiral. The umbonal part of the valve is very strongly prominent in adult specimens, less so in young ones, and is highly elevated above the hingeline. In the transverse direction the valve appears somewhat rectangular, the median part being strongly flattened or even impressed, and the sides descending nearly vertically to the lateral shell-margins. The wings are very small, pointed, and but little arched; if entirely preserved they mark the greatest breadth of the valve. The apex is strongly incurved, pointed, and well overhanging the hingeline. A well-developed sinus is not present on the valve. The sculpture consists of not very distinct radial ribs, which are not very numerous; they are crossed on the visceral part of the valve by indistinct irregularly wavering concentric wrinkles, which do not descend to the hinge-margin. The longitudinal ribs are provided from distance to distance with long slender spines, which are bent forward very near the root. These spines are more numerous on the lateral than on the median parts of the valve, and along the hingeline two tolerably distinct rows of them can be made out. The remaining surface of the valve is covered by very fine concentric striæ of growth.

The dorsal valve is deeply and evenly convave, only the little wings being somewhat flattened. The whole valve is covered by irregular not very strong concentric wrinkles, while a radial sculpture is entirely absent. Instead of it numerous radially arranged elongated grooves can be observed, which give to this valve a very characteristic appearance.

Of the interior characters of this species but very little is known to me. Only the existence of the internal ridge, characterstic of the genus *Marginifera* can be stated with certainty.

As has been said before, the species never attain considerable dimensions; the largest specimen known to me shows the following measurements:—

Length of the shell in a straight line	20 mm.
„ „ „ along the curve	44 „
„ „ smaller valve in a straight line	10 „
Greatest breadth of the shell at the hingeline	20 „
Thickness of the shell	13 „

Locality and geological position.—The species is not very rare at certain places in the lower division of the Productus-limestone. It seems to have been a species that lived in the immediate vicinity of the shore, as I have found it only in the Nílawán at different places, associated everywhere with many fragments of wood, &c., indicating a shore-deposit. The Nílawán is at the same time the first place to the east, where in the Salt-range the fossiliferous beds of the lower Productus-limestone make their appearance. The species is numerous there, but it is difficult to obtain specimens, as they are all very brittle and fall to pieces when extracted from the rock. I brought away only two well-preserved specimens.

Remarks.—The present species appears to be very nearly related to *Productus longispinus*, Sow., as defined by Davidson. The ventral valve shows a difference from the same valve in Sowerby's species by the more numerous spines which are chiefly crowded together on the lateral parts of the valve and by a more prominent visceral region. The dorsal valve of *Marg. excavata* is by its elongated grooves so characteristic and peculiar that it needs no comparison with the same valve of *Productus longispinus*.

Marg. splendens, Norw. and Pratt, has a distinct sinus in the ventral valve, also less numerous spines and a quite different dorsal valve.

It seems thus that our species is a well distinguishable form, which still bears a great resemblance to *Marg. typica* which will be described next. The differences consist in a less prominent visceral part, more numerous spines, more irregular concentric wrinkles in the apical region and an entirely peculiar dorsal valve in our *Marg. excavata*.

2. Marginifera typica, Waagen, n. gen. et sp., Pl. LXXVI, figs. 4—7; Pl. LXVIII, fig. 1.

1862. *Productus longispinus*, (Sow.) Davidson: Quart. Journ. Geol. Soc. Lond., Vol. XVII, p. 31, pl. I, fig. 19.
1863. *Productus longispinus*, (Sow., Dav.) Koninck: Foss. paléoz. de l'Inde, p. 37, pl. X, fig. 19.

Most specimens of this species have a very strongly inflated ventral valve with an extremely prominent apical region, well-developed wings, which are, however, often broken away, and a not very deeply concave dorsal valve which is excellently characterised by a row of grooves placed on the limit between the wings and the remainder of the valve. The species, however, never attained any considerable size, but remained always rather small.

The ventral valve is very much inflated, nearly spirally enrolled, and the visceral part is very strongly prominent above the hingeline; the curve is, however, not equal in either direction. Longitudinally the apex appears well bent in, but very near the apex already a considerable flattening of the valve takes place, which continues to the point where the valve appears most highly elevated above the hingline, then the flattening suddenly changes into the regular spiral curve. In the transverse direction the median part of the valve appears distinctly flattened and impressed, while the lateral parts are bent down nearly perpendicularly. The wings are very large, not pointed at their extremities, more or less spirally enrolled, and separated by a deep furrow from the remainder of the shell. When they are preserved, as is comparatively rarely the case, the general shape of the valve appears considerably broader than it is long, otherwise the breadth and length of the valve are about equal, and then the general outline appears somewhat squarish. Only young specimens have a more or less transversely oval outline. The apex is not much bent over, strongly pointed, prominent and somewhat overhanging the hingeline. At a short distance from the apex a well-developed, not very broad, but rather deep sinus commences, which extends down to the front, though it often

becomes somewhat more shallow in the frontal region. The sculpture of the valve consists in a fine radial plication which is about parallel up to a certain somewhat variable distance from the apex, and then begins to converge from both sides towards the middle of the median sinus. This fine plication continues mostly within the sinus down to the frontal margin, but on the elevated lateral portions of the valve several of the fine ribs unite indistinctly into a few coarse ones, on which then more or less numerous, irregularly placed, erect spines are situated (see Pl. LXVIII, fig. 1). In the apical region the radial folds are crossed at a greater or less distance by rather indistinct concentric ribs. On this indistinctly reticulated part of the valve there are more or less numerous fine spines quite irregularly distributed. Also, very regularly a distinct row of spines is to be observed along the furrow which separates the wings from the remainder of the valve. The wings are smooth or provided only with a faint concentric sculpture. Spines are always wanting on them.

The dorsal valve is very deeply concave. The wings are flattened or slightly concave, separated from the remainder of the valve by angular, strongly prominent divering ridges. Towards the front a not very strong median fold is developed. The concave part of the valve is rather distinctly reticulated in the apical region. Lower down only a fine regular radial plication remains. The whole reticulated part is irregularly strewn with little round shallow grooves, corresponding to the spines on the other valve. Two rows of these grooves are, however, most conspicuous; they extend inside along the ridges which separate the wings from the remainder of the shell. Prominent spines are absent on this valve.

I encountered great difficulties in making out the internal characters of this species, and only quite recently I succeeded in making some preparations showing these characters; they are represented in the subjoined wood-cut.

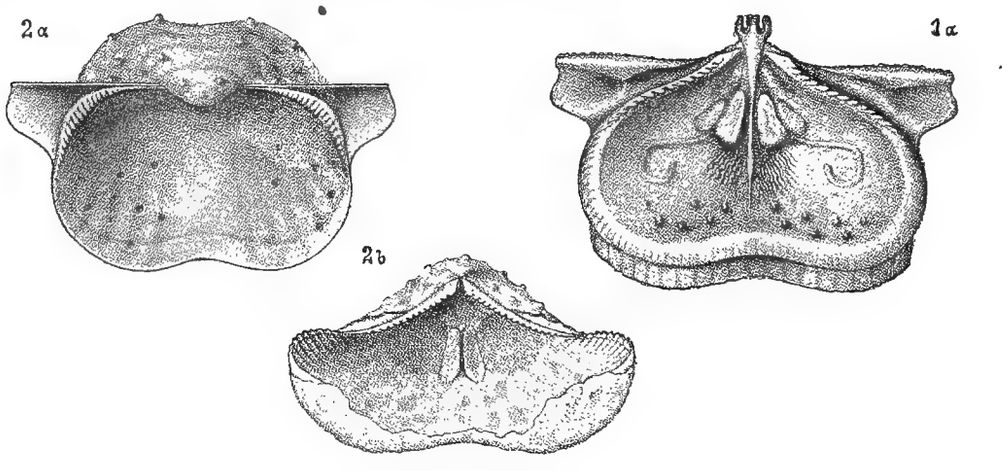


Fig. 23. MARGINIFERA TYPICA, Waagen, n. gen. et sp. Dorsal and ventral valves of one and the same specimen from the Cephalopoda-bed of Jabi: 1a, dorsal valve, internal view, strongly enlarged; 2a, ventral valve, internal view, enlarged; 2b, front view of the same, the wings broken off, also enlarged.

The ventral valve is very peculiar, and deviates very far from the corresponding valve of *Prod. longispinus*, Sow. As regards the muscular impressions only the

adductor impressions are quite distinctly visible. They are situated on both sides of the middle line of the valve and are narrowly elongated in shape. The divaricator impressions are not so distinct. They are certainly not striated longitudinally, seem to be roundish in shape, rather large and situated outside and on a level with the adductors. The ridges, characteristic of the genus, commence inside under the apex. They leave a narrow slit in the middle between them for the passage of the cardinal process of the other valve. They are not very high in this part of the valve, run down along the hingeline up to the commencement of the wings, then suddenly become high and sharp and bend round in a broad curve to join the lateral parts of the valve, leaving the wings free. In the frontal part the ridge dwindles down to a mere prominent line. The ridges are all along more or less strongly crenulated on top.

In the dorsal valve the internal characters are rather complicated. The cardinal process is short, quite sessile, not pediculated. It is somewhat belt-shaped; deeply hollowed out on its lower or external face and slightly vaulted on the upper or internal face. Its margin is deeply slit open on the lower face and cut into three lappets on its upper one. The cardinal process is continued on the inner side of the valve as a long but not very high median septum. Where the process is joined to the body of the valve there are on both sides a kind of dental grooves for the reception of the commencement of the internal ridges of the other valve. Outside and somewhat below these grooves the marginal ridges of this valve take their origin. They are so disposed as to fit within the ridges of the other valve. In the commencement they are sharp, but low and narrow, crenulated on their outer side, and remain so down to nearly the end of the wings; then they begin to become broader, and to be bent at the same time outward. In this condition they show a convex inner or upper face and a concave outer or lower one. The upper face is very finely transversely striated, whereby the margin appears under the lens to be very finely crenulated. This broad part of the ridge extends without interruption over the lateral and frontal parts of the valve. In the apical region outside of the ridge just described are rather deep and broad furrows, which serve for the reception of the ridges of the other valve. After this a very strongly thickened hinge-margin follows and extends to the end of the wings. In the median part of the valve, rather more approached to the apical region, the muscular impressions are placed on both sides of the median septum. The two pairs of adductor impressions are very strongly distinct from each other. The inner pair is large, somewhat reniform and very strongly raised above the surrounding parts of the valve. The outer pair on the contrary is much smaller, elongated, oval and situated in hollowed-out grooves. The brachial ridges are not well preserved in any of the specimens at my disposal. They seem to be low, filiform and simply hook-shaped. The internal surface of the valve is all over finely granulated. In the frontal region, within the marginal ridge, some larger spines seem to have existed.

The substance of both valves is always very thin.

The measurements of two specimens—No. I, the largest one known to me,

from Jabi, and No. II, a middle-sized specimen from the upper Productus-limestone of Swás, are as follow :—

	I.	II.
Length of the shell in a straight line	21 mm.	17 mm.
„ „ „ along the curve	42 „	33 „
„ „ smaller valve in a straight line	12 „	10 „
Breadth of the shell with the wings	31 „	24 „
„ „ „ without the wings	17 „	17 „
Thickness of the ventral valve	14 „	10 „
Distance of the two valves in the visceral region	10 „	7 „

Locality and geological position.—The present species is one of the more common ones of the Productus-limestone. It occurs chiefly in the middle and upper divisions of the formation, while in the lower division no characteristic specimens of the species have been found up to the present.

The geologically oldest specimen was collected by myself at Nursing Pohár, in a black limestone of which the lowest beds of the middle Productus-limestone are there composed. In the higher beds of the middle Productus-limestone the species has been found at Vurcha (1 sp.), on the road between Vurcha and Uchál (7 sp.), in the Chittawán (3 sp.), at Morah (1 sp.), in the Bazárwán (1 sp.), in the Bukh ravine (1 sp.), and at Swás (9 sp.). Trans-Indus the species has been collected by myself and by Dr. Verchere at Káfirkot (8 sp.), and by Mr. Wynne, north of that locality (8 sp., all on one piece of rock). In the section near Khura I collected the species in the top beds of the middle division (1 sp.).

The upper division is not so rich in specimens of this species. I collected the shell west of Khura in the lowest beds of the upper division (6 sp.), at Nanga (1 sp.), in the *Cephalopoda*-bed at Jabi (7 sp.), and in the same bed at Chidru (3 sp.).

The species does not extend into the topmost beds of the upper division but is replaced there by another form.

Remarks.—Mr. Davidson has identified the present species with *Prod. longispinus*, and it cannot be denied that a great resemblance exists between the Indian shell and Sowerby's species. This similarity is, however, more apparent than real. Even in the external characters of the two species there are differences which make a distinction possible. Before all there is the visceral part in the Indian shell much more prominent and elevated above the hingeline. Then also the radial striation is different; while in *Productus longispinus* the ribs are fine and of about equal width for the whole length, in *Marg. typica* several of these ribs unite as soon as they have passed the visceral part, so that only a few strong folds remain on which the spines are placed. The specimen figured by Davidson is in this respect a somewhat exceptional one, as at this size the union of the ribs has generally already taken place. But on the other hand Mr. Davidson figures so distinctly the marginal ridge, which forms the distinguishing character of the genus that I cannot but believe Mr. Davidson's specimen identical with my *Marg. typica*.

That this shell must be distinguished specifically and even generically from *Productus longispinus* is most clearly shown by the internal characters, which have been described above, and which are very peculiar.

In India the *Marg. excavata* described previously is most nearly related to the present species. The differences between the two consist in a finer radial sculpture, the absence of a sinus in the ventral valve, spines that are directed forward, and in an entirely different dorsal valve in *Marg. excavata*.

Of other species *Marg. splendens*, Norw. and Pratt, must chiefly be compared. This American form agrees with the Indian shell in so far that the fine radial striation appears also to be restricted to the visceral part, but it is already distinct by its thick shell and the occurrence of spiny tubes on the wings, which are never to be found on *Marg. typica*. Also *Marg. spinosocostata*, Ab., from permian beds of Djoulfa is similar to our Indian species, but the concentric sculpture in the vicinity of the apex is less strongly developed, a radial striation is wholly absent, the radial sculpture being composed only of coarse ribs, and a median sinus is barely indicated in the ventral valve of Abich's species, and thus it can well be distinguished from *Marginifera typica*..

3. Marginifera ornata, Waagen, n. gen. et sp., Pl. LXXVII, figs. 5, 6.

This is a very rare species; only two specimens of it have been detected up to the present in the Salt-range. It is of rather small size and of a transverse outline, but the exact shape of this outline I am not able to indicate, as in both specimens the wings, which so easily fall off in the genus *Marginifera*, have been broken away. Without the wings the outline is transversely oval or somewhat trapezoidal, the greatest breadth being situated not far from the front. The radial sculpture consists partly of a fine striation, partly of coarse ribs, but the most characteristic feature of the species consists in a very strong and neat concentric sculpture in the vicinity of the apex.

The ventral valve is very strongly curved, nearly spirally enrolled. In the longitudinal direction this curve is, however, rather irregular, the visceral part being considerably flattened. In the transverse direction the lateral parts appear strongly depressed, the outline running down nearly vertically, and the median part is highly elevated, flattened and impressed in the middle. The apex is pointed, strongly prominent and incurved, and overhangs the hingeline very distinctly. At a very short distance from the apex a very deep median sinus commences, which extends down to the front. The sculpture of this valve is very similar to that of the preceding species. It consists of a fine radial striation within the sinus and on the lateral portions of the shell as far as the visceral part extends. Lower down this sculpture changes on the two lateral lobes into coarse ribs, which bear many spines. On the visceral part of the valve, however, in opposition to *Marg. typica*, is a very strong and neat concentric sculpture, which is stronger than the radial one and determines the character of the shell. This sculpture consists of fine concentric

folds, which start from the hingeline and extend up to a row of spines that separates the wings from the remainder of the shell. At these spines each of the folds bifurcates, and then runs in an elegant curve to the other side. Besides the two regular rows of spines, which have just been mentioned, there are many other spines irregularly distributed over the surface of the valve.

The dorsal valve is deeply concave, most so in the apical region. The wings are flattened and highly elevated, separated from the remainder of the valve by a narrowly angular ridge. Within these ridges on each side is a row of round shallow grooves corresponding to the row of spines on the other valve. The median part of the valve is covered with a fine radial plication, which is interrupted at intervals by faint concentric folds and roundish shallow grooves. Spines are absolutely absent on this valve.

Of the internal characters of this species nothing is known to me, except what has been figured Pl. LXXVII, fig. 6*c*: these are, the very distinctly developed marginal ridges of both valves, which have come to light by the breaking off of the wings, and of that part of the shell which has been called in other *Producti* the "trail."

The measurements of a specimen from Amb, without the wings, are as follow:—

Length of the shell in a straight line	15 mm.
„ „ „ along the curve	29 „
Length of the dorsal valve	10 „
Breadth of the shell without the wings	16 „
Thickness of the ventral valve	10 „

Locality and geological position.—There have up to the present only two specimens of this species been detected. Both were collected by myself, one in the *Cephalopoda*-bed at Jabi, the other at Amb in the grey sandstones forming the topmost beds of the Productus-limestone.

It thus appears that the species is restricted to the higher beds of the upper division of the Productus-limestone.

Remarks.—This species appears to be very nearly related to the preceding one, and it could also perhaps be compared to *Prod. longispinus*. It can, however, be distinguished from that species by the same character as the preceding one, and by the strong concentric plication of the apical part.

This latter character is also the one by which a distinction of the present species from *Marg. typica* is possible, and to which the name *ornata* is intended to allude. It might perhaps seem to be not quite correct to found a species on the occurrence of this character alone; but if one observes that the specimens bearing this character are restricted only to the upper region of the upper Productus-limestone, and that one of these specimens came from the top-beds where Brachiopoda are altogether rare, it seems practical to distinguish these specimens from *Marg. typica* under a proper specific designation, in order to mark the difference of geological horizon of this special form.

Marg. excavata, W., differs from the present species by the same characters by which it differs from *Marg. typica*, W.

Abich's species of *Marginifera* cannot be compared in particular with the form here under consideration, as they are both nearly devoid of a concentric sculpture.

b.—Group of *MARGINIFERA SPINOSOCOSTATA*, Abich, sp.

4. Marginifera ovalis, Waagen, n. gen. et sp. Pl. LXXVII, figs. 1—4.

The general outline of this species is somewhat squarish or transversely oval. The visceral part of the ventral valve projects very far above the hingeline, and the sculpture of the valve consists in coarse radial ribs bearing rather numerous spines at irregular distances. A fine radial striation, as observed in the forms belonging to the preceding group, is absolutely absent. A concentric sculpture is indicated in the vicinity of the apex, but very little developed.

The ventral valve is very strongly inflated and nearly spirally enrolled. The curve is very regular in the longitudinal direction, and also transversely it is not much deformed. The sides descend rather abruptly, and the median part is flattened and distinctly impressed in the middle. The wings are always small, not enrolled. but also not much flattened, and of about rectangular outline. If they are preserved, which is not often the case, the greatest breadth of the shell is indicated by the termination of the wings. The apex is inflated, pointed, strongly incurved, but very little overhanging the hingeline. Mostly rather far away from the apex a distinct, sometimes even very deep, sinus commences, extending to the front. The sculpture consists of thick irregularly interrupted radial ribs, which are rather far distant from each other, and bear at irregular distances strong spines, which are strewn over the whole shell surface and are to be found in the apical region as well as on the wings, though they are rare on the latter. Sometimes a more distinct row of spines can be distinguished on the limit between the wings and the body of the valve. In the apical region also a concentric sculpture occurs, consisting of slight folds, but only rarely so strong as in my fig. 2, Pl. LXXVII.

The dorsal valve is deeply concave, with a more or less prominent broad median fold in the middle. The small wings are nearly quite flat, sometimes slightly reflected. They are separated from the remainder of the valve by a broad rounded ridge, within which often a row of grooves can be observed, as in *Marg. typica*, but this row is not constantly present. Otherwise the sculpture of the valve consists in irregularly arranged shallow grooves, between which sometimes a faint radial plication exists, but mostly this plication is absent; only on the "trail," outside of the marginal ridge, it is of more general occurrence. A concentric plication is barely indicated in any of my specimens. Prominent spines are also altogether absent on this valve.

Of the interior characters of this species, only the existence of the apparatus of marginal ridges can be stated, as has been figured in Pl. LXXVII, figs. 3 and 4.

The measurements of the largest specimen known to me are as follow :—

Length of the shell in a straight line	16 mm.
„ „ „ along the curve	32 „
Length of the dorsal valve	12 „
Breadth of the shell with the wings	17 „
„ „ „ without the wings	16 „
Thickness of the ventral valve	11 „
Distance of the two valves from each other	6 „

Locality and geological position.—The present species is entirely restricted to the lower Productus-limestone, and is most numerously represented in the lowest beds of that division. The number of localities where it occurs is, however, very small. In really great numbers the species occurs at Amb, in the black coaly sandstones which form there the lowest fossiliferous bed above the "lavender-clays." I brought away from there some twenty specimens. At the same locality the species extends into somewhat higher beds, as I collected there a specimen in the bed with *Chonetes ambiensis*, W., the *Chonetes*-bed as I have generally called it in this work. The species is, however, very rare in this bed.

Besides at Amb I collected the species only at Katta in yellow sandstones, very low down in the lower division of the Productus-limestone (bed No. 10 of the section in my note-book).

Remarks.—The most striking character of the present species by which it can be distinguished from the greater number of other forms is the entire absence of a fine radial plication in the apical region, and thus the absence of the reticulation which in many other species is so well developed round the apex. This character is one which must be attributed to the whole group of forms to which the present species belongs, and it has been very properly remarked by Abich that just this character prevented his uniting the *Marginifera spinosocostata*, with *Prod. longispinus*, with which species it otherwise seemed to be very nearly related. Prof. Möller, on the contrary, has united Abich's *Productus spinosocostatus* with *Productus horridus*. A certain similarity of Abich's species, as well as of the form here under consideration, to *Prod. horridus* cannot absolutely be denied, but this similarity is certainly only an external one. The young specimens of *Prod. horridus*, figured by Geinitz and King, to which Mr. Möller refers, have certainly got no internal marginal ridges, and are therefore no *Marginifera*. If specimens with such ridges should occur in the European Zechstein, which I cannot absolutely deny, as I have not got efficient materials from that formation, they would have to be distinguished from *Prod. horridus* as separate species as well as the Armenian and Indian specimens of *Marginifera*.

The distinction between *Marg. spinosocostata*, Ab., and *Marg. ovalis*, W., is not quite easy, and I was for long in much doubt whether I should not unite the two. At last I have decided to the contrary. I found the specimens of *Marg. ovalis* always to be broader than long, while the contrary is the case in *Marg. spinosocostata*. Then the sinus is always strongly developed in my species, while

it is entirely absent or barely distinguishable in the Armenian shell. Finally, the young forms of the two species are entirely different; to see this, one need only compare fig. 8, Pl. IX, of Abich's work with my figures. Thus I thought it best to distinguish the two, all the more as their geological age is probably different. The Armenian species has been stated by Möller to be of permian age; the lowest beds of the Salt-range Productus-limestone are probably somewhat older, so that the Armenian species would probably be the descendant of the Indian shell.

c.—Group of *MARGINIFERA HELICA*, Abich, sp.

5. Marginifera transversa, Waagen, n. gen. et sp., Pl. LXXVIII, figs. 4, 5.

The general outline of this species is very strongly transverse, oval or somewhat trapezoidal, its breadth being just twice the length. Nevertheless is the shell very strongly inflated, but nearly devoid of any sculpture, ornamented only by numerous long thin spines directed forward.

The ventral valve is extremely strongly inflated, its thickness being nearly equal to its length, but the curve is very irregular in the longitudinal direction. The apex is distinctly bent in and rounded; then follows a long flattened space which terminates in a strong geniculation of the valve; after which it descends abruptly, but yet forming a well-rounded curve to the frontal margin. In the transverse direction the valve appears broadly flattened on top, somewhat impressed in the middle, while the lateral parts descend nearly vertically to the margin. There are rather large wings on both sides of the apex; they are flattened and terminate in acute angles. A very long straight hingeline extends along these wings, and occupies the greatest breadth of the valve. The wings fall off very easily, as in all species of *Marginifera*, and then the greatest breadth of the valve is situated lower down, not far from the front. The apex is small, pointed, barely prominent, and not or barely overhanging the hingeline. A very shallow sinus is developed either not far from the apex, or where the valve appears geniculated. Though the shell seems on a first glance nearly quite smooth and shining, yet on a a close inspection two systems of very faint sculpturing can be observed. The radial system consists of not numerous fine narrow ribs, on which the spines are placed, and of a concentric system extending as far from the apex as the flattened space of the valve, and consisting of very irregular faint concentric wrinkles. The radial ribs generally appear only where the concentric wrinkles can no longer be observed. The spines, which are a very characteristic feature of this species, are distributed on the radial ribs, and in consequence they are absent on the flattened part of the valve, only exceptionally a sporadic spine occurring also on this part. On the wings spines are rare. There is on the contrary very regularly a row of spines at the limit between the wings and the remainder of the shell. On the deflected part of the valve the spines are very numerous, but they are quite irregularly arranged. The nearer the shell-margin the more numerous they

become. The spines themselves are very thin and very long. They have been drawn much too thick and short in Pl. LXXVIII, figs. 4 *e* and *f*. The direction has, however, been rightly represented there. The margin of many specimens is girt by them as by a thickly set fringe.

The dorsal valve of this species is but very imperfectly known to me. It seems to be rather deeply concave and nearly quite smooth, only showing two diverging rows of flat roundish grooves at the limit between the wings and the remainder of the shell. Prominent spines seem to be entirely absent, at least as far as is known to me.

Of the internal characters only the existence of marginal ridges, characteristic of the genus *Marginifera*, can be stated; they are well and strongly developed.

The measurements of a well-developed full-grown specimen from Amb are as follow :—

Length of the shell in a straight line	11·5	mm.
„ „ „ along the curve	24	„
Distance of the front margin from the hingeline	10	„
Greatest breadth with the wings (hingeline)	22	„
„ „ without the wings	18	„
Thickness of the ventral valve	10	„

Locality and geological position.—Up to the present this species has been detected only at a single locality of the Salt-range, this was at Amb in the lower division of the Productus-limestone. I found it there not very rare (9 sp.) in the *Chonetes*-bed.

Remarks.—It is of much geological interest that the present form also is so very nearly related to one of Abich's permian species; and the affinity is really a very close one. *Marg. helica*, Ab., agrees with our species in the smooth shining shell with its strong silky lustre, as well as in the always transverse general outline. The difference consists chiefly in the regular curve of the ventral valve in *Marg. helica*, while the same valve is geniculated in *Marg. transversa*. Also the regular row of spines on the limit between the wings and the remainder of the ventral valve, which is very regularly present in the latter species, constitutes a distinguishing character. These characters, of which chiefly the first is very striking, are, I think, quite sufficient for the specific distinction of the Indian shells from the Armenian ones.

There is here again the same circumstance to be taken into consideration, to which we have drawn attention already with respect to the preceding species. In this case also it is probable that the Indian shell is the geologically older one, whilst the Armenian one belongs to a geologically somewhat younger horizon. It is now a very strange fact that the two developmental series to which *Marg. ovalis*, W., and *Marg. transversa*, W., belong have had no descendants in more recent beds in India itself, as in the middle and upper divisions of the Productus-limestone the genus *Marginifera* is only represented by the descendants of *Marg. excavata*, W., while they have propagated well in far-distant countries, as

in Armenia, where their descendants are to be found in great numbers. This is a fact not without interest, but to explain why it has been so is absolutely impossible for the present.

Mr. Möller has united *Marg. helica*, Ab., with *Productus horridus*, Sow. I have explained already above the reasons why this should not be done.

d.—*ISOLATED* species.

6. MARGINIFERA ECHINATA, Waagen, n. gen. et sp., Pl. LXXVIII, fig. 1; Pl. LXXV, figs. 7, 8.

The general outline of this very elegant little species is transversely oval, the greatest breadth of the shell coinciding with the hingeline, if the wings are preserved, if not, as is very often the case, then the greatest breadth is situated about in the middle of the longitudinal diameter of the shell. The sculpture of the shell consists of a great many radial rows of fine species, which latter are otherwise arranged approximately in quincunx.

The ventral valve is very strongly inflated. The curve is, however, unequal in the longitudinal direction; the apex is very little incurved, and from the point of it to about the middle of the shell extends a flattened space, after which the valve is rather suddenly curved, whereby a kind of geniculation is produced. The frontal part is again rather flattened, not much curved. In the transverse direction the outline ascends rather rapidly from the margins, and is flattened on the median part of the valve, with a slight depression in the middle. The wings are not preserved in any of the specimens of ventral valves I have for description. In all these specimens they are broken off along the internal marginal ridge. The apex is pointed, prominent, but not bent over. At a rather considerable distance from it a median sinus commences, which is mostly rather deep and well developed, and which extends down to the front. The sculpture is very peculiar and easily recognisable; it is composed of two systems of very fine folds, of which one bears a great number of thin spines: this latter is the radial system, which is composed of 32 or 33 rather indistinct radial ribs, each of which bears at least ten spines before it reaches the frontal margin. The spines are so arranged as to alternate on two adjacent ribs where they appear placed in quincunx. The concentric sculpture is developed chiefly only on the visceral part of the valve. The wings, it seems, are quite smooth, bearing neither a radial nor a concentric sculpture, but where the wings are united to the body of the valve, the concentric sculpture commences. It consists of many fine wrinkles, which are chiefly distinct on the lateral parts of the valve, and often disappear entirely on the median part, but in other specimens they are also here quite distinct. Of other features of sculpture there may yet be mentioned the existence of two distinct rows of spines where the wings are united to the body of the shell.

The dorsal valve is nearly always disunited from the ventral one, and I have no specimen in which the two valves are in natural position. Isolated dorsal valves might easily be taken for strange *Producti* with flat valves, of the group of *Productus latirostratus*, Howse. This dorsal valve is very flatly concave with flatly spread out wings. These latter are very rarely broken off, quite the opposite of what is generally the case in the ventral valve; they are entirely flat, quite smooth without any sculpture, and separated from the remainder of the valve by a low angular ridge. On the interior side of this ridge a row of shallow round grooves is situated. The whole median part of the valve is covered down to the frontal margin by distinct concentric wrinkles, between which many shallow grooves, corresponding to the spines of the other valve, are disseminated.

Of the interior characters of this species but very little is known to me. In the ventral valve the marginal ridges, characteristic of the genus *Marginifera*, are very strongly developed, which is evidently the reason why the wings so very easily fall off. In the dorsal valve on the contrary these ridges are very weak and little developed. In the figure, Pl. LXXV, fig. 7, the specimen is seen from the interior side, but the shell is only preserved in the frontal region. As will be remarked in the enlarged figure, the ridge is indicated, but very low and little prominent. In this respect the present species most nearly approaches *Prod. longispinus*, Sow. Of the other remaining interior characters nothing is known to me.

The substance of the shell is very thin in both valves.

The measurements of a ventral valve, devoid of its wings, are as follow:—

Length of the shell in a straight line	14	mm.
„ „ „ „ along the curve	24	„
Distance of the frontal margin from the hingeline	12	„
Greatest breadth of the shell	19	„
Thickness of the ventral valve	9	„

Locality and geological position.—The present species has as yet been found only at a single locality in the Salt-range. This is in the Nílawán below Bhal, where the species occurs in a white sandstone representing the lowest fossiliferous beds of the Productus-limestone series. The fossils are found there more or less in nests clustered together, and some of these nests are entirely made up of the shells of the present species. It thus happened that in a small rock specimen I brought away, not less than ten specimens of the species were contained. The same bed in which the present species occurs is also very rich in *Fusulinæ*.

Remarks.—The present species is very peculiar in its sculpture, and cannot well, as far as I am aware, be compared to any other species of *Marginifera* or *Productus*. The only species which might perhaps be adduced as bearing some resemblance is *Prod. spinulosus*, Sow., or *granulosus*, Phill., but both these forms are different by the absence of radial ribs on which the spines would be placed. The same character distinguishes also the present species from my *Prod. opuntia*, previously described.

IV.—Sub-order: CORALLIOPSIDA.

Family: *RICHTHOFENIDÆ.*

I create this sub-order, as well as this family, to contain a single genus, *Richthofenia*, Kays., a fossil which exhibits such strange and conflicting characters that I am in doubt whether even the prominence I give to it, in creating a distinct sub-order for it, will be sufficient to bring out the quite separate position it holds, not only among the *Brachiopoda*, but also among the whole of the mollusca and molluscoids.

In the Records of the Geological Survey of India, Vol. XVI, part 1, 1883, I have given a preliminary description of these fossils, and in that paper I came to the conclusion that we had to deal with a form of shells more or less related to the *Brachiopoda*, but showing at the same time many characters which are generally found in corals, and exhibiting, moreover, some peculiarities which recall to a certain extent the *Rudista*. Ever since the publication of that paper I have continued my studies on these fossils; and though in the general structure of the shells little that was new remained to be ascertained, there was the microscopic structure of the shell-substance to be studied more in detail; this has not, however, resulted in a clearer elucidation of the systematic position of these animals.

After prolonged and very careful reconsideration of all the facts relating to these fossils, I have come to the conclusion that the probability is strongest in favour of their being *Brachiopoda;* and that if this be the case, they have to be placed in the vicinity of the *Productidæ*, at the end of the *Arthropomata*. My reasons for this course were the following:—

The question is reduced to a simple alternative, either these fossils are *Brachiopoda* or they are corals; the third position hinted at in my former paper, as to whether they might not belong to the *Rudista*, is no longer to be considered, as my appeal to the scientific public on this account has met with no response. The point should not, however, be wholly lost sight of.

Now, as regards placing these fossils among the corals, the reasons to be adduced against such a decision are numerous: First, there is the very vivid silky lustre of the shell, a thing which but very rarely and never in this degree occurs in corals. Then the three vertical septa of the larger valve have a rather median position, forming a kind of columella, and have no connection whatever with the outer walls of the shell, so that they can only be made visible by a section, and never by etching away with acid the epitheka, or any such structure, as can generally be done with corals; and I have never seen a coral with the septa restricted exclusively to the columella, and totally absent beyond it. A third point of discrepancy consists in the hingeline, which is straight and smooth, without the slightest trace of denticulation,—a hingeline which never occurs in this form in an operculated coral. A fourth strange character is the existence of a distinct pallial impression along the upper

margin of the larger valve. But what overrules all the other points is the existence of muscular impressions in both valves, as will be described further on. As against these characters in which they deviate from corals, we find only the general conical outline, the root-like hollow processes protruding from the surface of the larger valve at irregular distances, and a cellular structure of the median shell-layer in connection with numerous partitions or tabulæ filling the lower part of the same valve; characters which occur also in the rugose corals. These are not, however, of very material importance: the more or less regular conical form is only an apparent one, as I shall have occasion to show presently; the root-like appendages occur as well in species of *Productus;* and even the cellular structure and the partitions occur in such strangely developed forms of Brachiopods as *Prod. proboscidens*, as has been kindly communicated to me by Prof. Lindström, no sufficiently well-preserved specimens of that species being at my disposal for dissection. Thus we see that the peculiarities by which the *Richthofeniæ* seem to be linked more or less closely to the corals, are not exclusively restricted to that latter class of animals, but occur also in known aberrant forms of the *Brachiopoda*.

As regards the placing of the *Richthofeniæ* in the *Brachiopoda*, several reasons can be adduced in favour of it. First of all the silky lustre of the shell resembles exactly that occurring in *Productus* and allied genera; then the fine punctation of the shell is also exactly like that of *Productus*. For other similarities we must examine each valve separately. The smaller valve is hemmed in at its upper end by a not very long straight hingeline, which is interrupted in the middle by a prominent knob composed of two short elevated ridges, which are either parallel or converge somewhat in one or the other direction. The knob is limited on both sides by somewhat sloping triangular shelly faces extending between the knob and the lateral terminations of the hingeline. The median prominent knob may well be taken as a kind of cardinal process, which fits into a semi-circular emargination of the hingeline of the other valve. This emargination is bridged over by a vaulted shelly piece corresponding exactly to the pseudodeltidium of *Strophalosia* or *Aulosteges*. This pseudodeltidium does not, however, show externally on the larger valve, but appears only when the rather thick shell is broken away, and a partial internal cast is produced. Then also a kind of area appears, in the middle of which the pseudodeltidium is situated; it begins at the apex of the valve and extends down to the hingeline, corresponding in breadth to the length of that line. The homology of these shell-parts with the corresponding parts of the *Brachiopoda* was first pointed out to me by Prof. Lindström; but there remains the difficulty, that these parts do not show outside the larger valve, but only appear when the greater part of the shell is broken away and only the innermost coating remains. To understand this we must study the shell-structure in the larger valve. When we examine that part where the margins of the two valves touch each other, we find that the smaller valve is sunk into the large one, and that the margins of the latter extend far above and beyond the smaller valve. These projecting parts of the larger valve were secreted by a rather moveable fringe of the mantle of the

animal, which did not deposit one shell layer above the other quite regularly, but in the most irregular way became vaulted and wavy in all directions, so causing the formation of innumerable more or less hemispherical cells in the median shell-layer; only in the outer wall of the shell did it form again a continuous shelly deposit. This mantle-fringe was not restricted to the frontal and lateral parts of the animal, but protruded also over the hingeline, forming outside of it the same cellular layer as on the other parts of the shell, and thus the forms of the area and pseudodeltidium were quite obliterated on the outer surface of the shell. From these considerations it would appear that we must take the partial internal cast (Plate LXXXIII, fig. 15) as representing the real shape of the shell, and the outer form of the specimens as produced by an exuberant growth of the shell-substance.

In intimate connection with the above peculiarity in the growth of the shell is the existence of a chambered lower part in the larger valve. This valve seems to grow in length more rapidly than the animal augments in size, and thus the animal is forced to chamber off those parts of the valve which it cannot fill with its body.

The next point which requires consideration in connection with the Brachiopod nature of these fossils is the muscular impressions. In the smaller valve we have two large muscular impressions on both sides of the middle line, not far from the hinge-margin and the cardinal process. These impressions, with their many roundish emarginations along the upper and outer borders, have, it must be confessed, not much similarity to the muscular impressions of other *Brachiopoda*. That they are, however, really muscular impressions, appears highly probable from a consideration of the other valve.

In my note on the genus *Richthofenia* in the "Records," I described the median septum of the larger valve, and added that from this septum on both sides some low secondary septa originate, showing on the whole a pinnate arrangement. Some preparations subsequently made have shown me that we have not to deal here with secondary septa, but with deep emarginations of a muscular impression of exactly the same pattern as the one on the smaller valve. But the impression only just touches the bottom of the valve with its lower margin and extends for the greater part up the lateral face of the septum, so that the septum itself with its two lateral faces serves for the support of a pair of muscles, which must be taken as adductors, according to the placement of the impressions of the same muscles in the smaller valve.

Beyond and somewhat below these impressions, on the inner side of the two lateral septa, the deep pocket-shaped grooves are situated, as described in my former note. These deep grooves must probably also be taken as muscular impressions, and they can only be the pair of (anterior) divaricators, extending from the grooves up to what was described above as a sort of cardinal process.

The septa themselves have, so far as I am aware, no analogue whatever in other Brachiopoda; their presence also must probably be explained through the excessive growth of the larger valve, to which cause all the other peculiarities have been

attributed. To make sure of all these points, it would be necessary to examine quite young specimens of these fossils. I think it should not be difficult to find such; but I regret to say that there are none among the materials at my disposal. Thus my deductions must remain to a certain extent conjectural and uncertain.

To recapitulate what has been said on the relations between the *Brachiopoda* and the *Richthofeniæ;* we have seen that in the smaller valve there exists a kind of cardinal process, a straight not denticulated hingeline, and very large muscular impressions on both sides of a well-developed, sometimes bipartite, median septum. In the large valve we have also a straight hingeline, which is interrupted in the middle by a kind of pseudodeltidium. This latter is situated in the middle of something like an area, and extends to the apex of the valve. In the interior the adductor impressions are situated on the lateral faces of a short median septum, and the divaricators are inserted in deep pocket-shaped grooves situated outside and in front of the adductors. If, then, all these interpretations of the different parts are correct, there can be but little doubt that the fossils bearing these characters must be considered as *Brachiopoda;* and they must moreover, on account of the position of the muscular impressions, be placed in the order *Arthropomata*.

From the same considerations and interpretations, the degree of affinity of these fossils to the different groups of the *Brachiopoda*, and to other classes of the molluscs and molluscoids, may be judged. Though there cannot be any doubt that the *Richthofeniæ* form part of the *Arthropomata*, yet the difference from other forms of this order is very great indeed. Already the external shape is very extraordinary, and not like that of any other Brachiopod. There is, as far as I am aware, no case known up to the present in which the area and pseudodeltidium is entirely covered up by an excessive growth of the shell, or in which the smaller valve is sunk in so deeply into the larger one. The shell-structure of the larger valve seems also very unusual, though, by Dr. Lindström's discovery of a similar structure in *Prod. proboscidens*, this feature is no longer so peculiar. The muscular apparatus of the *Richthofeniæ* is far more abnormal. In the smaller valve only one pair of very large impressions with a strangely indented outline is observable, while in the other valve there exist two pairs of impressions, one pair for the adductors, another for the divaricators, as in other *Brachiopoda*. The position of these impressions is, however, very peculiar. The adductor impressions are situated on the lateral faces of a prominent median septum, and the divaricator impressions are sunk in deep narrow pocket-shaped grooves, having their faces probably turned laterally and not horizontally. Of a brachial apparatus, properly speaking, nothing exists in these shells, unless the three upright septa in the middle of the larger valve should possibly be compared to the median prominence in *Crania* and allied genera, which latter organ also serves for the support of the brachial apparatus.

If all these peculiarities indicate already a very great difference between the *Richthofeniæ* and the other *Brachiopoda*, there are some other characters which make this difference far more apparent. In speaking of the characters of the smaller valve, I mentioned that on both sides of the cardinal process between it and

the hingeline there extended sloping, triangular, smooth faces. These faces might very well have served for the insertion of a ligament; but after all that has been said on this point in the description of the genera *Aulosteges* and *Productus*, it would not be very perplexing if a ligament had existed in the *Richthofeniæ*. By far more strange is the existence of a pallial impression in the *Richthofeniæ*,—a character which has, as far as I am aware, not yet been described in any Brachiopod, except, perhaps, in *Thecidea* and *Crania*. This pallial impression is to be found immediately below the prominent margin on which the smaller valve rests. It is composed of a series of furrows, all parallel to the margin, and occupying together a breadth of about 5 mm. These furrows are, however, absent below the hingeline. It is hardly possible to suppress the opinion that we have here really to deal with a pallial impression. There is further another very perplexing fact in the emarginated condition of the adductor impressions in both valves. I know of no Brachiopod in which such impressions occur; but in *Pelecypoda*, they may exceptionally be observed. If, for instance, we examine attentively old specimens of living species of *Spondylus*, we find very distinctly emarginated muscular impressions not dissimilar to the impressions of *Richthofenia;* the muscular impressions of the true *Rudista* are also not quite dissimilar.

To sum up all that has been said on the affinities of the *Richthofeniæ*, we have found that these shells most probably belong to the *Brachiopoda*, but that they constitute so strange a group within this class, that though they may be assignable to the *Arthropomata*, yet they cannot be placed immediately in the vicinity of any known group. They show on the one hand external affinites to the corals, and on the other structural affinities to the *Pelecypoda*. This conflicting evidence alone will justify my considering them at least as a proper sub-order, for which I introduce the name of "*Coralliopsida*."

Prof. Kayser, in his description of these fossils in Richthofen's "China," thinks it most probable that they should be brought into connection with the *Craniadæ*. Though this cannot be done on account of the position of the muscular impressions as described above, yet I must confess that I am myself also much inclined to consider these forms as to a certain extent transitional between the *Arthropomata* as a whole and the *Craniadæ*.

We shall see in the description of the *Craniadæ* occurring in the Salt-range, that there existed forms which make such a transition yet more probable.

Genus: RICHTHOFENIA, Kayser.

After a careful study of all the available materials of these fossils, it is considerably more easy to give a characteristic of them; the characters of the genus may now be framed in the following manner:

The shell is composed of two valves, one smaller and one larger. The smaller valve is entirely flat or even concave; the larger valve is elevated, conical, and very

irregular in its outline. Thus the general shape of the shell is irregularly conical, showing at the same time a more or less circular transverse section.

This general shape is, however, only a distorted one, caused by an excessive growth of the large valve, by which certain characters of the outline are covered up, and are not observable in the intact shell.

The two valves articulate in a straight hingeline, sometimes very short, sometimes somewhat longer, interrupted in the middle by a prominent cardinal process in the smaller, and by a small semi-circular emargination, covered by a kind of pseudodeltidium in the larger valve.

The circumferential outline in the two valves is thus very different. The smaller valve is limited on the one side by the straight hingeline, which is followed laterally by rather deep emarginations, while the lateral and frontal margins are well rounded, forming together a transversely oval outline. In the larger valve, on the contrary, though the straight hingeline exists, and also laterally two thickened parts fitting into the emarginations of the other valve, yet the circumferential outline is circular or transversely oval, and none of these parts show externally on the valve, but appear only when the large part due to the exuberant growth of the shell-substance is removed. Then one can observe that the straight hingeline corresponds to a flattened area extending to the apex of the conical valve, and in the middle of which a vaulted pseudodeltidium is placed. In the Indian species of *Richthofenia* this pseudodeltidium is narrow in comparison to the breadth of the area, while it is very broad in the Chinese species. On both sides of the area there extend deep impressions, which are filled with the thickened shell when complete. The remainder of the valve shows a more or less circular or transversely oval outline, often with a low indentation opposite the hingeline.

The external appearance of the two valves is also very different. In the smaller valve the external surface shows a fine granulation, between which can be observed very fine concentric striæ of growth. In the surface of the larger valve two regions are distinguishable. The first region is that turned to the outside of the valve. It is covered by a great many irregular concentric wrinkles, which are from distance to distance drawn out into prominent points, through which hollow, root-like, tortuous spines proceed. Sometimes a very fine longitudinal striation can also be observed on this surface. The cause of this striation can be seen when the outermost layer of the shell is removed. Then a very fine punctation appears, which is sometimes arranged in approximately vertical rows, by which arrangement the striation is produced. The second region of the surface of the larger valve is that at the upper end. This valve does not terminate where it is met by the other valve, but extends often considerably in advance of it, either vertically or laterally. The internal surface of this extended part of the valve shows the same fine granulation as that covering the external surface of the smaller valve. The valve is fastened by the apex as well as by the root-like spines to foreign bodies.

The substance of the shell in both valves has a dull silky lustre when entirely preserved; and this lustre is very vivid when the outermost layer of the shell is

removed. Then, also, a fine punctation appears, in which, among the numerous very fine punctures, some larger ones are disseminated.

Such are the external characters of the genus. The internal characters are only very imperfectly known in the Chinese species, and I shall only introduce into the characteristic of the genus those features which are known to exist in the Chinese as well as in the Indian shells.

In the smaller valve the cardinal process bears a pair of short, prominent ridges which fit into the cavity of the pseudodeltidium. In front of these a low but distinct median septum extends nearly to the front of the valve; it is sometimes bifid towards the hingeline. On each side of this septum in the Indian species, there is a large muscular impression.

In the larger valve the median part is occupied by three short, upright septa, which may perhaps correspond to the nose-like process in the middle of the valve of *Crania;* in the vicinity of it two pairs of muscular impressions are situated. The lower part of the valve is chambered off by many partitions, through which the septa extend vertically. The bottom of the uppermost chamber in which the animal lived is very uneven. The lateral parts form deeply hollowed grooves, whilst from the hingeline to the septa there extends a sloping plane, and from the septa to the front a more or less broad, rounded, elevated saddle is observable. The whole internal surface of this valve is covered with small, prominent, roundish tubercles and some granulations. From the outer walls of theanimal chamber short vertically-placed ribs project towards the interior at irregular distances, bearing at their upper termination the entrances to the hollow, tortuous, root-like spines, which have been described above.

These characters will suffice to recognise the genus under all circumstances. The affinities of the genus have been discussed in the introduction to the family, and thus there remain only some words to be said about the species contained in the genus.

The genus was founded by Prof. Dr. E. Kayser, on two specimens collected by Baron von Richthofen at Lo-Ping in China, and which were identified by Prof. Kayser with the fossil that had been formerly described by Mons. de Koninck from the Salt-range under the name of *Anomia lawrenciana*. Owing to the great liberality of Geheimrath Beyrich at Berlin, I am in a position to make a close comparison of the Chinese fossils with the Indian ones, as he with great kindness sent me these two very precious specimens for further study.

From this comparison it now appears with certainty that the Chinese fossils, though beyond doubt generically identical with *Anomia lawrenciana*, belong to a different species, for which I wish to introduce the name of *Richthofenia sinensis*, Waagen. It differs from the true *Richth. lawrenciana* by the very short hingeline, and the larger cardinal process in the smaller valve. The median cystoid shell-layer is also much less strongly developed, and the partitions in the apical part of the larger valve have a different shape in the Chinese fossils, so that it cannot be subject to any doubt that *Richt. sinensis* is a species different from *Richt. lawrenciana*.

As regards the geological and geographical distribution of the genus, it has up to the present been detected only in upper palæozoic beds of China and India. In the former country it occurs in undoubtedly upper carboniferous deposits, whilst in India it extends through the whole Productus-limestone, thus probably reaching the permean age.

1. Richthofenia lawrenciana, Koninck, sp., Pl. LXXXII, fig. 1, LXXXII A and LXXXIII.

1863. *Anomia lawrenciana.*, Koninck: Quart. Journ., Geol. Soc., Lond. vol. XIX, p. 6, pl. IV, figs. 7, 8, 9.
1863. *Anomia lawrenciana*, Koninck: Foss. paleoz. de l'Inde, p. 18, pl. III, figs. 7, 8, 9.
1881. *Richthofenia lawrenciana* (Koninck, sp.), Kayser: Zeitschr. d. Deutsch. Geolog. Ges., vol. XXXIII, p. 351, (pars).
1882. *Anomia* (*Richthofenia*) *lawrenciana* (Kon. sp.), Waagen: Nen. Jahrb. f. Min., 1882, vol. I, p. 115.
1883. *Richthofenia lawrenciana* (Kon.), Waagen: Records, Geol. Surv. of India, vol. XVI, part I, p. 12, pls. I. II.
1883. *Richthofenia lawrenciana* (Kon.), Lindström: Richthofen's China, vol. IV, p. 74.
1883. *Richthofenia lawrenciana* (Kon.), Kayser: Richthofen's China, vol. IV, p. 195 (pars.. quotations from India), pl. XXIV, figs. 6, 7, 8 (non 4, 5).

Already Mons. de Koninck, in describing this very strange fossil in 1863, remarked that it was among the most interesting that were brought by Dr. Fleming from India, and that though in its general appearance more similar to an *Anomia*, yet by the occurrence of spines on the larger valve it to a certain extent resembled *Productus*, and thus in these few sentences the whole difficulty encountered in the classification of this fossil was already foreshadowed.

Though I have described this fossil already somewhat in detail in the Records, yet I must here in great part repeat that description; on the one hand, because this monograph should be complete; on the other, because I have since then learned to understand more clearly several points in the structure of the fossil, and thus the description will have to be completed and corrected in several points.

The fossil consists of two valves, one larger and one smaller. The larger is of an elevated conical shape, with the apex fastened to some foreign body. The smaller valve is flat, more or less sunk into the larger one. The two valves articulate by a not very short hingeline, which, however, does not appear in the outer aspect the conical valve; it is only marked inside it. At both ends of the hingeline the smaller valve is cut out in a semicircle to receive thickened parts of the shell of the larger valve. The outer side of the larger valve is rugose, provided with many concentric wrinkles and bears a variable number of hollow, depressed, diverging, tortuous tubes, which, on the one hand, resemble the root-like appendages of some rugose corals, and on the other, can be compared to the hollow spines of some *Producti;* the resemblance to the latter is chiefly striking because of the silky lustre of the shell substance of which they are composed. On the whole, the shell of the fossil is rather dull when intact, and of a vivid silky lustre when the outermost layer of the shell is worn off. There also appears a very close punctation, similar to that occurring in the shell of *Productus;* it is barely visible to the naked eye.

The punctures are not all equal; some larger ones of two sizes are disseminated irregularly between great numbers of smaller ones. These punctures are sometimes arranged in tolerably regular vertical rows, and then even the outer shell-layer on which the punctures are not visible appears as if very finely striated longitudinally.

On the smaller (flat) valve the hollow tubes, which are so very characteristic of the larger valve, are altogether absent. When the shell substance of this valve is perfectly preserved, it is strewn over with very numerous small papillæ that project slightly from the surface of the shell. The same papillæ are to be found on the upper and inner face of that part of the large valve which projects beyond the smaller valve. We shall see in the description of the microscopical structure of the shell that these papillæ form the entrances to the little canals which pierce the shell substance of the large valve. It has not been possible to make microscopical sections of the smaller valve, but the presence of the same papillæ suggests the presence of the same canals in this valve also. On its interior side this smaller valve bears a distinct, but not very high, median septum, extending from near the margin opposite the hingeline nearly to the middle of the valve. Here it is often replaced by two parallel ridges, which in other specimens, however, are combined in one broader septum. On both sides of this septum large muscular impressions, more or less rounded, are very strongly marked and distinctly indented on the side nearest the hingeline; on the side opposite to it they are less strongly marked, but seem to be also indented. In the middle of the hingeline there are, vertical to it, two short and thick prominent more or less parallel ridges, not dissimilar to hingeteeth; they are, however, about equally high throughout. They are not in connection with the median septum, but are separated from it by a smooth space. They do not protrude much above the hingeline, but yet sufficiently so to be considered as forming together a kind of cardinal process. On the sides of these ridges no trace of dental grooves can be seen. Along the frontal or outer margin itself, not far distant from it, more or less numerous curved thorns occur, directed towards the interior of the shell, similar to those in some *Producti*.

The structure of the larger valve is far more complicated. It consists of two distinct parts; the lower, from the apex of the valve to about the middle of its height, being composed of very numerous narrow water-chambers divided off by very thin shelly partitions; and the upper, forming a large hollow for the reception of the animal. The partitions in the lower part of the shell are very irregular, on the whole convex below and concave above; not so, however, for their whole extent, as about in the middle they are bent upwards, forming something like a columella, as it is called in corals. This bending up is caused by three vertical septa, which extend from the apex of the shell through all the partitions up to the animal-chamber. These septa are narrow, upright, shelly lamellæ, of which the middle one commences not very far from the hingeline and is in direction perpendicular to that line, whilst the two lateral ones converge from both sides towards the frontal termination

of the median one. In transverse sections of the valve it often appears as if a triangular space was entirely partitioned off from the remainder of the shell by these lateral septa in connection with the hingeline. This is, however, in reality not the case. The septa are in no connection whatever either with the hingeline, or with any other part of the outer wall of the shell; they are narrow, upright, shelly lamellæ, resembling somewhat the blade of a knife. The appearance as if they were in connection with the hingeline is only brought about by the partitions of the water-chambers, which in this region often ascend quite vertically, and can then only with difficulty be distinguished from the septa. The partitions extend between and around the septa, bent in various directions, up to the hingeline.

The animal-chamber is tolerably large; the bottom of it is, however, situated at very different levels. The space between the septa and the hingeline is much more shallow than the remainder of the chamber; but the latter also is not even, as from the centre of the shell a rounded crest extends to the wall opposite to the hingeline, forming a shallow saddle. On each side of this crest is a deep hollow, which occupies the whole lateral parts of the animal-chamber. The whole bottom is covered by an irregular, tolerably minute grooving.

The three vertical septa project into the animal-chamber as three high, upright plates, which converge towards the centre of the shell and are highest near this centre. The median one is highest and never curved in any way, but the lateral ones are often, or nearly always, concave on their inner and convex on their outer side. The upper margin of all three is crenulated. They never unite but remain always apart, though they approach each other very nearly in the centre. From their highest point they descend vertically to the bottom of the animal-chamber; on the other side, however, between them and the hingeline, there is an ascending plane, none of the septa reaching the hingeline. These septa seem to have served, to a certain extent at least, for the insertion of the muscles.

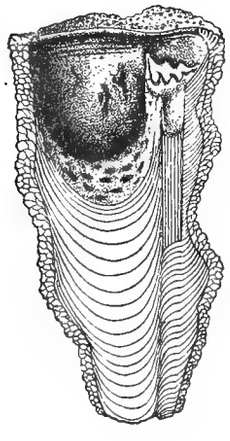


Fig. 24. Richthofenia lawrenciana, Kon. Somewhat schematic section through the ventral valve from the hingeline to the front, showing the animal-chamber and the partitions below. In the former, the upright median septum is observable, with the emarginated muscular impression on its lateral face. The pocket-shaped groove for the reception of the divaricator is cut open. The lateral septum, with its vertical striation, is exposed below it.

On both sides of the median septum, and extending up the lateral planes of this septum, there are large muscular impressions exactly of the pattern of the impressions of the other valve; these are deeply indented on their lower side, and have on the whole a somewhat roundish triangular shape. The indentations reach often far up the lateral faces of the septum. The two lateral septa are limited on their inner side by deep pocket-shaped grooves, in which probably also the insertion of muscles took place. The place of insertion was probably the septum itself, as, in several specimens, I found that the inner side of these septa showed irregular thickenings, probably produced by muscular insertions. The outer sides of the lateral septa are provided with a very fine longitudinal striation.

The hingeline is quite straight and smooth, and shows only in the middle a slight rounded sinuation for the reception of the cardinal process of the other valve.

The inner side of the outer walls of the animal-chamber, as well as the inside of the outer walls of the larger valve in general, is provided at very irregular and unequal distances with tolerably broad and sharp, but not very prominent, vertical ridges, some of which begin a short distance below the upper border of the animal-chamber, and disappear before reaching the bottom; while others begin lower down, and then reach to the bottom and extend even below it. The upper termination of each of these ridges bears a rounded foramen, which forms the entrance to the hollow root-like tubes which can be observed on the outer side of the shell, as has been described above. This foramen, however, does not pierce the wall directly, but the tube descends nearly vertically and appears at the outer side of the shell only in the vicinity of the apex.

All round the upper border of the animal-chamber, but a good distance below the margin of the valve, a thickened prominent ledge occurs, below which again a number of impressions parallel to the margins can be observed. The whole seems to be exactly comparable to a pallial impression.

The substance of the shell is of a very singular structure. It is composed in the larger conical valve of the three layers. The outer one is very thin, dull, and compact outside, and of a silky lustre inside, provided with the characteristic punctation and striation mentioned above. The median layer, the thickest of all, though very irregular in its thickness, is composed of approximately hemispherical cysts, arranged very irregularly and interrupted at intervals by perfectly straight, radial, very pointedly conical, thin shelly tubes, which apparently are most numerous in the thickened shelly parts at both ends of the hingeline, and which require further explanation. They begin at the outer shell-layer with a slightly broader base, and extend in a more or less ascending direction towards the inner portions of the shell. They appear more or less polygonal in the transverse section. All do not with their sharply pointed ends reach the innermost shell-layers; indeed most of them stop about half way. Nor do all of them originate from the outer shell-layer, for some start from the wall of some cyst in the median layer of the shell. They form, as has been said

above, very thin tubes, which apparently communicate with the larger pores disseminated between the more minute punctation of the shell as described above. The much larger hollow tubes terminating in the root-like processes, penetrate this median part of the shell substance in a nearly vertical direction. The innermost layer of the shell is somewhat thicker than the outer one, but otherwise similar to it. The median and outer layers of the shell fall off easily, and then internal casts of strange description are produced, which preserve the inner shell-layer. It has been said in the discussion of the systematic position of these fossils, that of all the teguments which can be distinguished in this larger valve, probably this inner shell-layer is the essential part, from which the real shape of the valve must be judged, and that the other layers, the median as well the outer one, are probably due only to an exuberant growth of the shell.

In the flat smaller valve the median shell-layer is absent.

Under the microscope many other features of the shell-structure can be observed. It then appears very clearly that the shell of the larger valve is composed of a great number of very thin lamellæ, closely packed together in the innermost and in the outer shell-layers. These lamellæ disunite on the one hand towards the interior of the shell to form the partitions with which the lower part of the valve is filled, and on the other hand for the formation of the cysts of the median shell-layer. The lamellæ are mostly more or less vertical in the inner shell-layer, then bend outward in a somewhat horizontal direction, but very irregularly, disuniting and again re-uniting and thus forming the cysts, and at last in bending up again vertically they unite to form the outer shell-layer. Each lamella is of a very singular structure. It is finely papillate on the inner or upper side, and in consequence grooved on the outer side when the lamellæ touch each other, but nearly smooth on the outer side when they are disunited. To this character may be traced the punctation of the shell when the outermost shell-layer is removed, as this layer leaves on the underlying shell-lamella the impression of the papillæ of its inner side, and these appear as punctation. The real punctation is in connection with the papillæ, not with the grooving; as apparently on the smooth outer or lower faces of the lamellæ the punctation consists only of very fine pores which are not situated in grooves.

In the Records of the Survey (*l. c.*), in describing the microscopical structure of the shell, I stated that all the lamellæ show a fine striation, vertical to their plane, and that this striation is very likely owing to each being formed of vertical prisms. Fresh preparations, admitting of the application of a more strongly magnifying power, have now shown me that this striation is not caused by prisms, but by a very densely set perforation of the shell. Each papilla on the upper or inner side of the lamellæ forms the entrance to a very fine narrow canal, which mostly penetrates one or more of the lamellæ and then splits up into two or three branches, terminating either at one of the cysts or below the outermost layer of the shell. I was so fortunate as to secure the aid of one of the most celebrated microscopists now

living on the Continent, Dr. Conrad Schwager of Munich, for the execution of Plate LXXXII, on which are represented microscopical sections of the substance of the shell of several molluscs, molluscoids and corals, and with them a longitudinal section through the shell of *Richthofenia*. For the correctness of the drawings the name of Dr. C. Schwager is an absolute guarantee, and from this drawing it most clearly appears that these canals split up into several branches. This plate may serve at the same time as a standard to judge the correctness of the drawings on Plate LXXXIIA, executed by Mr. A. Swoboda.

On this latter plate there is a figure representing a section through the shell of *Richthofenia* parallel to the surface. The papillation and the canals which pierce the lamellæ in connection with it can be distinctly seen, and owing to the unevenness of the shell, the cysts also are partly uncovered. Another feature, however, the meaning of which I was quite unabl eto make out, is the radially-striated organs which appear in this section. They certainly do not belong to the root-like tubes with which the larger valve is provided; they might perhaps be attributed to the polygonal straight shell-tubes, which have been described above. Another figure on the same plate represents a vertical section through that thickened part of the shell which fits into the emarginations of the smaller valve at both ends of the hinge-line. What is chiefly remarkable in this section is the great frequency of thin, straight tubes ascending nearly vertically.

If we compare all these sections with those of *Productus*, *Derbyia*, *Calceola*, and *Radiolites*, represented on Plate LXXXII for comparison, we find that the greatest similarity exists between *Productus*, *Derbyia*, and *Richthofenia*, whilst the shells of *Calceola* and *Radiolites* are not at all comparable. This result is perfectly in accordance with the opinion already given by Kayser from a simple inspection of the shell with a lens, that the structure of the shell of *Richthofenia* had the greatest similarity to that of *Strophomena or Productus*.

To give measurements of these fossils is barely possible, as their external shape is so extremely variable that two specimens never entirely resemble each other. From the numerous figures of this species it will not, however, be difficult to get an idea of the range of variation in size and shape these fossils are subject to.

The species is gregareous in its occurrence in nature, and the individuals are often so closely packed together, that the root-like appendages of one individual are fastened to the individuals around; but I never found two individuals entirely grown together.

Locality and geological position.—The species is very common at certain localities in the Salt-range; most so in the middle division of the Productus-limestone. In the lower division it is also not rare at some places, but on the whole much rarer than in the middle division. In the upper division it has also been found at many localities, but is everywhere rare, and in the topmost beds of the formation it is entirely absent.

It has been collected by myself at Amb in the lowest fossiliferous beds of the whole formation, just above the lavender-clays (11 specimens).

At Katta I collected a specimen in the lowest beds of the compact limestones which compose the middle division (bed No. 12 of the section in my note-book).

In the middle region of the middle division I collected the species at Virgal in the coral beds (11 specimens), as well as in the crinoid beds (1 specimen), in the Chittawán (19 specimens), at Katta (1 specimen), and Trans-Indus at Káfirkot (2 specimens). Mr. Wynne collected the species in the same beds at Morah (1 specimen), and Trans-Indus at Bilot in the crinoidal cliffs (1 specimen), as well as on the top of those cliffs (2 specimens), and at Omarkheyl (1 specimen).

In the upper region of the middle division the species has been found by Dr. Warth and Mr. Wynne at Musakheyl (5 specimens), and by myself in the section at Khura in the uppermost beds of the division (1 specimen).

In the upper division the species has been collected by myself, west of Khura, at the very base of the division (1 specimen), as well as somewhat higher up (1 specimen). Also, Mr. Wynne found a specimen in this division at Jabi. The geologically youngest specimens were detected by myself in the *Cephalopoda* bed of Jabi (4 specimens), as well as in that of Chidru (1 specimen). Higher up the species does not extend.

Remarks.—There are not many remarks to be made about this species, as everything regarding its systematic position has been stated already in the introduction to the family.

As regards the geographical distribution of the species, it is restricted to the Salt-range, and has not yet been described from any other country The shells which have been figured by Kayser from China under the name of *Richthofenia lawrenciana*, Kon., do not belong to this species, but are distinct from it by a shorter hingeline and an altogether thinner shell-substance.

2. Richthofenia sinensis, Waagen; Pl. LXXXII A, fig. 4.

1883. *Richthofenia lawrenciana* (Kon. sp.), Kayser: Richthofen's China, vol. IV, p. 195, pl. XXIV figs. 4-5 (non Koninck).

I have created this name for the species of Richthofenia that has been described by Kayser from the upper-carboniferous beds of Lo-Ping in China.

This species is characteristically distinguished by a very insignificantly developed hingeline, which is often so short as to be barely perceptible, as for instance in the specimen figured by Kayser, fig. 4 b. A hingeline is, however, present in this case also. Though this character is the most striking one, yet there exist also others by which the species may be recognised.

The thickened parts of the larger valve which fit into emarginations of the smaller valve at both ends of the hingeline in the Indian *Richthofenia lawrenciana* are absent in the Chinese shell. Then there is something like a median sinus

observable in the smaller valve; and the larger valve bears more prominent and sharper wrinkles on its surface.

Of the interior characters of the Chinese shell little is known; it can be stated that on one of the specimens at least the general internal arrangement is similar to, but not identical with, that of *Richthofenia lawrenciana*. The shape of the partitions in the large valve is well observable on the smaller of the Chinese specimens. One of the partitions has been exposed by the breaking off of the apex of the larger valve. The tolerably smooth surface exhibited by this fracture was taken by Kayser to be the impression of a foreign body to which the shell had adhered; but an inspection of the specimen immediately convinced me that it was one of the partitions that was here exposed. The surface of these partitions is finely granulated; the form, however, is considerably different from those of *Richthofenia lawrenciana*. The rounded saddle which extends from the vertical septa to the wall of the shell opposite the hingeline occupies nearly the entire breadth of the shell, and the broad hollows on both sides of the saddle in the Indian species are here reduced to mere narrow fissures along the lateral walls of the shell. Not far from the frontal wall of the shell, opposite the hingeline, the partition bears a very characteristic little groove, which appears as a small knob on the lower face of the partition as exposed in the specimen serving for description. In the vicinity of the hingeline a triangular space is marked off, owing to the bending up of the partitions on the three vertical septa; the triangle is limited on one side by the hingeline, and towards the apex by the area. All this is exactly as in *Richthofenia lawrenciana*. The area, however, owing to the insignificant development of the hingeline, is very narrow, but yet very distinctly limited on both sides by sharp edges. It bears in the middle a broad flatly-arched pseudodeltidium. All these parts are covered up and concealed as in the Indian species by an exuberant growth of the shell, but they can be distinctly seen in fractured places of the Chinese specimens.

The *Richthofenia sinensis* is, moreover, distinct from *Richthofenia lawrenciana* by the very small development of the cystiferous part of the shell-substance in the larger valve.

Locality and geological position.—The species was originally described from China, as has been remarked above; but it seems to occur also in the Salt-range. At least I should be inclined to associate with this species a specimen collected by myself at Nursingpohar in the black beds forming there the lowest part of the middle division of the Productus-limestone.

Remarks.—The specimen from Nursingpohar that I assign to this species is not sufficiently well preserved to allow of a quite exact determination, but the configuration of its partitions, the only character which can be exactly observed, is so absolutely identical with *Richthofenia sinensis*, that I cannot avoid comparing this shell with the Chinese species.

The occurrence of this Chinese form in the Salt-range would be of much geological interest.

Order: LYOPOMATA.

Sub-Order: *GASTEROPEGMATA* sive *CRANIACEA.*

Family: *CRANIADÆ.*

It is with some hesitation that I undertake the description of the *Lyopomata*, as the materials on which this description must be founded, though partly very numerous, are yet somewhat incomplete owing to the great difficulties that have to be surmounted in exposing the inside of these shells, which are mostly of an extreme thinness and fragility.

Though the Craniadæ make an exception to this general rule, yet in this family also I cannot present a full description of the several forms; it remains even doubtful whether the shells which I place in this family do really belong to it. This uncertainty is caused by the circumstance that of the *Crania*-like shells occurring in the Salt-range, only the lower and adhering valve is known to me, while the upper or free one has not yet been found. If, therefore, the description of the *Lyopomata* should be found rather unsatisfactory, the reason is to be sought for in the incompleteness of the materials, whereby the control of observation by the preparation of several specimens is nearly impossible. The forms of this order occuring in the Salt-range are, however, of too much interest to be overlooked; so I give what I can, looking forward to fuller information from new studies undertaken under more favourable circumstances.

The *Craniadæ* form a very compact little group of shells, which even may attain the rank of a sub-order; the generic distinctions are, however, rather difficult, and founded on not very prominent characters. Zittel, in his Handbook of Palæontology, considers the family to contain only the single genus *Crania*, which is divided again into a number of sub-genera. Dall, on the contrary, distinguishes the following genera within the family:—

Crania, Retzins, 1781 (Schrift. Berlin. Ges. naturf. Freund., II, p. 72).
Craniscus, Dall, 1871 (Bull. Mus. Comp. Zool. III, pt. I, p. 26).
Ancistrocrania, Dall, 1877 (Bull. Unit. States Nat. Mus. No. 8, p. 13).
Pseudocrania, M'Coy, 1851 (Ann. & Mag., Nat. Hist., vol. VIII, p. 388).
Choniopora, Schauroth 1854 (Zeitschr. Deutsch. Geol. Ges., vol. VI, p. 546).

If we now compare with these genera the shells figured on Plate LXXXIV of this work and supposed to belong to the *Craniadæ*, we find that they deviate totally, and indeed appear so very dissimilar to all the shells comprised within the family, that it might even be questioned whether they should be placed at all with *Craniadæ*.

The only characters which induce me to place the specimens in that family are the calcareous composition of the shell, the peculiarity that one of the valves is fixed by its entire surface to foreign bodies, and finally the absence of any trace of hingeteeth.

Though these characters combined make it highly probable that these shells belong to the *Craniadæ*, yet the decisive characters based upon the arrangement of the muscular impressions cannot be observed in the Indian fossils, and thus their systematic position must remain to a certain extent doubtful.

For these Indian forms, of which the lower valve only is known up to the present, I introduce the generic name of *Cardinocrania*.

The genus has only been observed in the Salt-range, and is not very common there.

Genus: CARDINOCRANIA, Waagen, n. gen.

This genus is founded on lower valves only, the upper valves not being known to me.

The lower valves are of small dimensions, fixed by the entire surface to foreign bodies. Their general outline is more or less transversely oval, with a short straight hingeline on one side, and a more or less strong indentation on the opposite or frontal side.

The existence of such a hingeline is very peculiar, and ought to be indicated in the name.

The valve all round spreads out with a thin and flattened margin, which also is fixed to the supporting body.

In the interior of the valve the most conspicuous part is a thin, triangular, shelly plate, fixed by its broad base to the cardinal region of the valve, and extending with its narrow and indented extremity to not far from the front. It is supported in the middle by a short low septum. This plate probably served for the support of the different muscles, but of the impressions nothing can be distinguished in any of the specimens at my disposal. This is all I can say of the structure of the genus.

There cannot be the slightest doubt that the shells bearing these characters are generically different from all the other groups of the *Craniadæ*. Though the smooth, not granulated, shell-margin to a certain extent recalls *Pseudocrania*, yet the very distinct hingeline, strongly marked off by emarginations from the remainder of the valve, is a character by which the Indian shells deviate not only from all the genera of the *Craniadæ*, but from all the *Lyopomata* together.

In the Salt-range the genus is only represented by a single species, which has, however, a very extensive range. It commences already in the lower division of the Productus-limestone and extends through the whole formation. The species never occurs in great numbers.

The genus has not yet been observed in any part of the world except the Salt-range; and even from there it is very incompletely known, as only lower valves have been found up to the present.

CARDINOCRANIA INDICA, Waagen, n. gen. et sp.; Pl. LXXXIV, figs. 1, 2.

The species is of a rather small size, barely exceeding a breadth of 8 mm., and still smaller in length.

The lower valve, which alone is known, is always of a more or less transversely oval shape, and very little elevated in thickness. It is fixed by its entire under-surface to foreign bodies, and when well preserved shows always more or less largely spread-out margins, which creep along over the body to which the valve is fixed. The outline of the valve is thus not very well defined, and its contour is chiefly determined by the figure assumed by a highly elevated ridge, which on all sides surrounded the animal and on which the other valve must have rested. Within this ridge the excavated part of the valve is situated.

The figure described by this ridge is transversely oval on the whole. The lateral parts are well rounded, and in the middle of the frontal region there exists a more or less deep emargination. Opposite the front line the lateral parts ascend in a gentle curve towards the middle line, then suddenly bend out again and join a tolerably long well-developed straight hingeline under acute angles. The hingeline itself forms a narrow sharp edge, limited on its outer side by a steeply descending smooth plane, and overhangs slightly on its inner side. In the acute angles on both sides, where the lateral shell-walls join the hingeline, there terminate deep furrows, which commence in the middle under the hingeline. From the spot where these furrows unite, a flat triangular space extends, occupied by a thin, somewhat lozenge-shaped, shelly plate, which probably served for the support of the muscles. This plate is fixed for a certain extent to the upper part of the lateral walls of the valve, whilst its median part hangs far down, nearly to the frontal region. Its lateral outline is deeply cut out in a rounded line, and the median part is slightly bi-lobed, the lobes being a little bent up so as to produce a short furrow in the middle. If the plate is broken, one sees that it is supported from the bottom of the valve by a short, rather thick septum. The lateral parts of the valve are much more deeply sunk in than the plate which has just been described.

The expanded margins of the valve seem to be extremely finely granulated, but the space occupied by the animal appears to be quite smooth. On the elevated ridge which surrounds the excavated part of the valve, a slight impression can be observed at certain places, chiefly in the vicinity of the hingeline, evidently caused by the other

valve. From this it appears probable that the upper valve partly fitted into the lower one.

Neither muscular nor vascular impressions can be distinguished.

The dimensions of three specimens, Nos. I and II from Morah and No. III from Jabi, are, as far as they can be taken, as follow :—

	I.	II.	III.
Length of the shell	7 mm.	4 mm.	5·5 mm.
Breadth of the shell	8·5 „	7 „	9 „
Length of the hingeline	4 „	3·5 „	4 „
Thickness of the lower valve	1 „	0·5 „	1·5 „

Locality and geological position.—It is very difficult to indicate exactly the geological range of the present species, as the specimens must be well preserved to allow of an exact determination. This arises from the circumstance that the young specimens of *Strophalosia*, adhering to foreign bodies, if not very well preserved, look exactly like the present species when not well preserved, and it is impossible in such cases to say which is which. Thus it is very difficult to say in what special beds the present species occurs and where it is more abundant, as though I am convinced that many of the badly preserved specimens adhering to other shells belong to the present species, yet I cannot be certain of it. Thus, for instance, I cannot say for certain whether the little things found occasionally in the lower Productus-limestone adhering to the shells of *Spirifer*, &c., belong to the present species or not, though it seems probable that they do. The occurrence of the species in the middle Productus-limestone, however, is beyond any doubt, as the well-preserved specimens from Morah, represented on Plate LXXXIV, fig. 1, are from that division. It is equally certain that the species occurs in the upper Productus-limestone, as the excellently preserved specimen represented in fig. 2 of the same plate was found by myself in that division in the *Cephalopoda* bed at Jabi.

Remarks.—There is no need, as far as I am aware, to indicate for the present species any characters distinguishing it from other forms, as the species is so isolated that it cannot easily be mistaken for any other. Even generically it is but very little related to other groups. Among the *Craniadæ*, *Pseudocrania* might perhaps in a general way be compared. If in *Pseudocrania* we take as a whole all the space on which the muscular impressions are distributed, it somewhat resembles in shape the triangular muscular plate in our species; but there is no hingeline in *Pseudocrania*, and thus the similarity ceases. As regards the hingeline, slight traces of such have been figured in jurassic species of *Craniscus*, but that part is not at all so strikingly developed in these forms as in our *Cardinocrania*.

This hingeline puzzled me a good deal, and at last I came to compare it with the same part of two other fossils from the Salt-range, *Lyttonia* and *Richthofenia*. The similarity of the hingeline and surrounding parts with *Lyttonia* is chiefly striking, and perhaps I should better have placed the *Cardinocraniæ* altogether in the *Thecideidæ*, sub-family *Lyttoniinæ*, instead of in the *Crainadæ*, but the complete absence of any trace of hingeteeth in *Cardinocrania*, which are present, though

rudimentary, in *Lyttonia*, prevented me from doing so. Otherwise there is little similarity between *Cardinocrania* and *Lyttonia;* so the former may as well be placed among the *Craniadæ* until fuller information about it will be available.

A similar configuration of the hingeline is also observable in *Richthofenia*, and for a time I was even doubtful whether *Cardinocrania* was not the juvenile state of *Richthofenia;* but after a lengthened consideration I came to the conclusion that this was very improbable, at least traces of the vertical septa and of the pseudodeltidium ought to be observable in the quite young state. That *Richthofenia* shows otherwise a certain affinity to the *Craniadæ* has been stated above. On the whole, the obscure relations that may perhaps exist between these three genera are very remarkable, and some questions may yet have to be solved in this direction. There may really exist a transition between *Cardinocrania* and *Richthofenia* on the one hand, and between the former and the *Thecideidæ* on the other; so that the limit between the *Arthropomata* and the *Lyopomata* would no longer have to be considered so strictly drawn as has been done up to the present.

Sub-order: DAIKAULIA sive DISCINACEA.

Family: *DISCINIDÆ.*

This small family is, like the *Lingulidæ*, of very ancient date. The forms belonging to it all possess a very thin, horny, calcareous shell, and are characterised by the position of the peduncle; it is not marginal, but approaches more or less the centre of the lower or ventral valve, which is either slightly open from the margin to near the centre, or bears a slit-like foramen extending from the centre to near the margin, or finally a small foramen pierces the shell somewhere within this distance.

This position of the peduncle seems to me the essential point in assigning a genus to this family or not, the punctation of the shell, which is also present in most genera, being only of minor importance. Thus I am not quite inclined to follow Zittel's Handbook, which puts *Trematis* and *Schizocrania* in the *Obolidæ*, retaining only *Discina* and *Paterula* in the present family. Dall, on the contrary, seems rather to share my view in the matter; thus he places the following genera in the family:—

1. Discina: Lamk., 1819 (Hist. an. s. vert., vol. VI, p. 236). Silurian to recent.
2. Discinisca: Dall, 1871 (Bull. Mus. Comp. Zool. Cambr., vol. III, p. 37). Silurian to recent.
3. Trematis: Sharpe, 1847 (Quart. Journ. Geol. Soc. Lond., vol. IV, p. 66). Silurian.
4. Orbiculoidea: Orbigny (1847 ?), 1849 (Comptes Rendus XXV, p. 269, Prodr. Pal. Strat. Sil., p. 21). Silurian to cretaceous.
5. Schizocrania: Hall and Whitfield, 1875 (Palæont. of Ohio, vol. II, p. 71, pl. 1, figs. 12-15). Lower-silurian.
6. Acrothele: Linnarsson, 1876 (Bihang till k. Svenska Vetensk. Akad. Handling., vol. III, No. 12, p. 20).

The genus *Paterula*, Barrande, which has also been placed by Zittel in the family *Discinidæ* is but very imperfectly known; but from the general configuration of its little valves, I should rather be inclined to place it in the family *Lingulidæ* than in the *Discinidæ*. Mr. Davidson, however, whose admirable last part of the British Brachiopoda has just reached me, places the genus definitively in the latter family. With regard to *Schizocrania*, he expresses some doubt whether it is not a *Discinocaris*.

In the Salt-range the family *Discinidæ* is but doubtfully represented by a single (or perhaps two) species of rather uncertain general affinities. I place the fossil in this family on account of a rather broad and deep incision on the margin of the ventral valve for the passage of the peduncle. The external appearance of the shell recalls to a certain extent that of *Trematis*, which also seems sometimes to bear such a slit-like incision on its lower valve, but in the Indian shell the apex is more eccentric and the sculpture entirely different from *Trematis*.

From this it appears rather probable that we have to deal here with a new genus, for which I introduce the name of *Discinolepis*. In introducing this new name, I feel very keenly how desirable it would have been to ascertain also the internal characters of the shells; but on the one hand specimens of this form are very scarce, and on the other it is extremely difficult to clean the inside from the adhering rock; and as it was very uncertain whether I should be successful in making a preparation, I did not venture to destroy one of the few specimens.

If the genus I thus introduce is not founded on very firm ground, the new name at least avoids the union of this form with another group of shells, with which it does not well agree, and the name of which would perhaps be suggestive of geological conclusions.

Genus: DISCINOLEPIS, Waagen, n. gen.

The shell is of very small size with two unequal valves, which are very flat, leaving scarcely any room for the animal between them.

The lower or ventral valve is hardly at all vaulted in any direction, and appears flatly spread out like a small fish scale. Only the apex is a little elevated. It is removed from the margin towards the median part of the valve. The margin of the valve nearest the apex is broadly cut out by a deep incision reaching to the top of the apex.

The upper or dorsal valve is in shape similar to the other one, with a slightly elevated eccentric apex, but without an incision.

The surface in both valves is either smooth or covered with a fine granulation.

From this description it appears that the present genus is different from all the other genera of the *Discinidæ* hitherto described. From *Discina*, *Discinisca*, and *Orbiculoidea*, it differs in having an incision and not a slit-like foramen in its lower valve for the passage of a peduncle. In *Trematis* a similar incision or emargination seems sometimes to occur, but the sculpture of the valves is quite different from that

occurring in *Discinolepis*. *Schizocrania* has an incision, but it is much larger than in the Indian form.

The genus is represented perhaps by two species in the Salt-range, but only one of them is sufficiently well preserved to be described.

DISCINOLEPIS GRANULATA, Waagen, n. gen. et sp.; Pl. LXXXVI, figs. 5, 6, 7.

The general outline of this species is more or less transversely oval to nearly circular. The two valves are of equal size and shape; both very small, not exceeding a diameter of 5 mm.

The upper or dorsal valve is not well accessible to my observation, as no entire specimen of it is preserved in the Salt-range collection. There is only the somewhat elevated and obtusely pointed apical part preserved, while the flatly expanded larger part of the valve is always broken. These fragments show the margin of the valve preserved on one side in the vicinity of the apex. This margin is entire, and nowhere cut out. The apex is but very little removed from the margin, and forms the culminating point of a narrow and but slight elevation, overhanging very little towards the centre of the valve. The surface of the fragments accessible to my observation is shining smooth without granulation.

The lower or ventral valve can be more completely described, as far better specimens are preserved. This valve is nearly quite flat, only a little space in the vicinity of the apex being slightly elevated. The margins are well rounded, and only on one side is there a broad slit or incision reaching to the top of the apex, but without the slightest indication of an area. The apex is not situated far inside the valve, but approaches the margin rather nearly on the side on which the incision is situated. It is but slightly elevated, obtusely pointed, and has a rather flatly sloping face towards the margin and a rather steep one towards the centre of the valve. The whole surface of the valve is covered with fine papillæ, between which can be observed faint striæ of growth, all starting from the margin on which the incision is situated.

The dimensions of two ventral valves are as follow:—

	I.	II.
Entire length	4·5 mm.	4·5 mm.
„ breadth	6 „	5 „
Elevation of the apex	0·5 „	0·5 „
Extent of incision	1 „	0·5 „

Locality and geological position.—The species is restricted to the so-called *Obolus* beds of Wynne's description, and seems to be not scarce in these beds, but well-preserved specimens are only rarely met with. The species has been found up to the present at Khewra in the valley above the salt-mines, and at Jutána. From the former locality there is a slab of black micaceous shale, on which dozens of fragmentary specimens of the species are observable. In other beds it seems, however, to

occur only sporadically, as the two well-preserved specimens figured on Pl. LXXXVI are solitary.

Remarks.—The little species here described is very isolated in all its characters, and cannot be in particular compared to any shell hitherto made known, as far as I am aware of.

Family: *SIPHONOTRETIDÆ.*

This family, which was proposed by Kutorga in 1848, seems to be in a rather unsettled state as regards its systematic affinities, and thus it happens that nearly every observer gives it a different place in the system.

By Dall, in his index, the family is placed at the head of the *Lyopomata*, next to the *Productidæ;* whilst Zittel in his Handbook distributes in the family *Obolidæ* all the genera classed by Dall as *Siphonotretidæ;* and Davidson, in the last part of his great work, again places the family between the *Craniadæ* and the *Trimerellidæ.* In the *Lyopomata*, where a shelly brachial apparatus is either entirely absent or only rudimentary, the mode of insertion of the peduncle seems to me the best principle of classification, and thus all the *Lyopomata* can very conveniently be brought into several sub-divisions, according to the mode in which the peduncle either protrudes between the valves, or pierces one of the valves, or is even altogether wanting.

The *Craniadæ* have a kind of shelly support for the brachial apparatus, but no peduncle at all. These characters widely separate them from the remainder of the *Lyopomata*, and thus a sub-order for that family as I have above established, can well be justified. Another type is represented by the *Discinidæ.* They possess a peduncle, and any trace of a shelly support for the brachial apparatus is wanting. The peduncle passes through a slit or a foramen in the ventral valve, and is thin and comparatively short. From the *Discinidæ* to the *Siphonotretidæ* there exists, however, a nearly perfectt ransition, as the genus *Mesotreta*, Kut., is different from *Discina* in its external appearance chiefly by the circumstance that the slit-bearing valve is more elevated than the other one, and the foramen just pierces the apex, whilst in *Discina* or *Orbiculoidea* the slit-bearing valve is the flatter one, and the slit-like foramen is shifted towards the margin. From *Mesotreta* to *Acrotreta* and *Siphonotreta*, there are but small steps, and thus it can barely be denied that the *Siphonotretidæ* as a whole are rather nearly related to the *Discinidæ*, and can very well be considered to form together with these a sub-order, for which I have introduced the name "*Discinacea*" or "*Diakaulia.*"

The *Obolidæ*, though also rather nearly related to the *Discinidæ*, very probably had a large peduncle protruded between the valves, as in the *Lingulidæ;* and thus I am rather inclined to bring them into closer relation to the latter, and to consider them as a connecting link between the *Discinacea* and a sub-order for which I shall introduce the name of "*Lingulacea*" or "*Mesokaulia.*"

The *Siphonotretidæ* comprise quite a number of genera, of which the following may be recorded :—

Mesotreta, Kutorga, 1847 : Verh. Kais. Russ. Mineralog. Ges., St. Petersburg, 1847, p. 271, pl. VII, fig. 4.

Acrotreta, Kutorga, 1847 : *l. c.*, pp. 260-275, pl. VII, fig. 7.

Siphonotreta, De Verneuil, 1845 : Geol. of Russ. and the Ural Mount., vol. II, p. 286.

Volbarthia, Möller, 1873 : Verh. Kais. Russ. Mineralog. Ges., St. Petersburg, 1873, pp. 1-7, l. I, figs. 1-6 ; Neu. Jahrb. f. Min., 1874, p. 449.

Mr. Davidson in the last part of his grand work quotes also *Kutorgina*, Billings, as belonging to the family. I cannot judge of the genus, as I have never seen specimens of it. From the figures I should be rather inclined to place it in the family *Obolidæ*.

A genus that might perhaps be considered as a connecting link between the *Siphonotretidæ* and the *Obolidæ* is *Helmersenia*, Pander, though the existence of a foramen may bring it nearer the former.

In the Salt-range there occur some shells that I should rather be inclined to place in the family *Siphonotretidæ*, though the forms are but very imperfectly known to me, and the materials very scanty. I am, however, quite at a loss as to what genus these shells ought to be placed in. The chief character consists in an area in one of the valves which is slit open in the middle, and seems to be widened on the top into a foramen. Thus these shells hold about a middle position between *Discina*, *Siphonotreta*, and *Lingula*, and it seems to me not advisible to place them in any of the hitherto described genera. To avoid then a misleading position of these shells in a genus to which they very probably do not belong, I rather prefer to make a new genus, though the foundation of it may be rather imperfect ; I shall thus introduce the name of *Schizopholis* for these specimens.

Genus : SCHIZOPHOLIS, Waagen, n. gen.

The shells belonging to this genus are all of very small size. They consist of two valves, of which one is imperforated and rather flat, the other is slightly elevated with a somewhat prominent marginal apex, below which is a small triangular area slit open in the middle by a triangular fissure, which seems to be sometimes a little widened at the top, forming a kind of foramen, placed just at the extremity of the apex.

The shell surface is very finely granular, and it seems as if it had borne spine-like appendages as in *Siphonotreta*, but these are not preserved in any of the specimens at my disposal.

Of the internal characters of the genus nothing is known to me, as there are only three specimens available ; and as the rock, a black micaceous shale, adhered very firmly to the internal side of these shells, it appeared impossible to make a preparation of the inside.

There has been found up to the present only one species of the genus in the Salt-range.

SCHIZOPHOLIS RUGOSA, Waagen, n. gen. et sp.; Pl. LXXXVI, figs. 2, 3, 4.

1862. *Siphonotreta*, sp. (Waagen) Wynne: Geology of the Salt-range; Mem. Geol. Surv. of India, vol. XIV, p. 87, *et passim*.

This is a very small species of elongately oval or somewhat trapezoidal outline, with one nearly flat and one slightly elevated valve. The latter is provided with a small area, which is apparently cut open in the middle by a broad slit ending at the top in a small foramen. The surface of both valves is rugose with numerous radially arranged wrinkles.

The dorsal valve is nearly quite flat, the apex being only very little elevated. The outline is well rounded, but not quite regularly, the valve being somewhat narrowed in the vicinity of the apex and spread out on the opposite side. The apex is pointed, not quite but very nearly marginal, and but very little prominent. The surface of this valve is much less strongly rugose than that of the other. The radial wrinkles are less prominent and less numerous. They are often slightly swollen where the striæ of growth cross over them, and there is some appearance as if spines had been placed on them. The space between the wrinkles, and apparently the whole surface of the valve, are very finely granular; the character can, however, be detected only with a powerful lens.

The ventral valve is slightly vaulted in the transverse direction and appears very flatly and eccentrically conical longitudinally. Its outline differs somewhat from that of the other valve, as only the part opposite the apex is well rounded. Laterally the outline is rather straight, and in the apical region the median part is prominent, with sloping sides, which join the lateral outline under an obtuse angle. The apex is pointed and prominent, somewhat overhanging and slightly cut out on one side for the passage of a small foramen, the form of which cannot well be seen on account of the deformation of the apex by pressure. Below the apex there is a vertically descending area, smooth, triangular in shape, and marked off on both sides by not very distinct edges. It is apparently cut open in the middle by a broad triangular slit, which seems to extend up to the foramen of the apex, but this cannot be well seen on account of the deformation of the single specimen.

The surface of the valve is very rugose, due to numerous strongly prominent, irregular radial wrinkles crossed by numerous concentric striæ of growth, producing generally a swelling where the two systems of wrinkles meet. On these points there is some appearance as if spiny processes had been broken off. Under a strongly magnifying lens the whole surface of the valve appears finely granular.

Of the interior characters of this species nothing is known to me.

The dimensions of two dorsal valves are as follow:—

	I.	II.
Entire breadth of the shell	5 mm.	4 mm.
„ length „ „	5 „	4 „
Thickness of the shell	0·5 „	0·5 „

An isolated ventral valve shows somewhat different dimensions, which are as follow :—

Entire length	6 mm.
„ breadth	5 „
Breadth of the area	2 „
Height of the area	1 „

Locality and geological position.—There are not more than three specimens of this species known to me, which were all collected in Wynne's so-called "*Obolus* beds." All three were collected by Mr. Wynne and myself in the gorge behind the salt-mines of Khewra.

Remarks.—I regret very much that I cannot give a better description of this interesting little shell. It is very easily distinguishable from all the other forms that occur with it by its rugose surface, which is not exhibited by any other similar shell except by *Siphonotreta*. I have placed this genus and species in the family *Siphonotretidæ* only in a provisional way. That the genus cannot be identified with *Siphonotreta* is evident; but its position in the family may also appear doubtful. On the whole, the genus is rather nearly related to *Discinolepis*, described before, and is distinct from it chiefly by the existence of an area. At all events its position in the sub-order *Discinacea* cannot be wrong.

Sub-Order: MESOKAULIA sive LINGULACEA.

Family: *OBOLIDÆ.*

This family was long ago established by King, but it has not been adopted except by Dall, Zittel, and Davidson. The range given to it by the different authors differs greatly, and it is rather difficult to point out the genera which might really belong to it.

On the whole, the characters of the family are rather simple, and not very difficult to recognise. They consist in a horny calcareous shell with somewhat unequal valves, between which in the apical region the peduncle protruded. The margins of both valves are generally thickened in this region, and the ventral valve bears a furrow in the middle below the apex. Each valve exhibits generally large muscular impressions in the vicinity of its lateral margins.

Zittel in his Handbook has framed the family characters in a very similar manner, nevertheless he has placed all the *Siphonotretidæ* in the family *Obolidæ*, though they have a perforated ventral valve. Dall, however, and Davidson have very properly separated the *Obolidæ* from the *Siphonotretidæ*.

According to the authors quoted, the family would contain the following genera :—

1. Obolus, Eichwald, 1829 : Zoolog. Special. I, p. 274. Silurian.
2. Obolella, Billings, 1861 : New Spec. of Silur. Foss. I, p. 6-7, fig. 7. Cambrian, silurian.

3. Monobolina, Salter, 1865: Mem. Geol. Surv. Great Brit., vol. III, p. 334. Cambrian, silurian.
4. Schmidtia, Volborth, 1869: Verhaudl. Kais. russ. Mineralog. Ges. St. Petersburg, 2 ser., vol. IV, p. 208. Silurian, devonian.
5. Keyserlingia, Pander, 1861: Bull. Imp. Acad. Sci., St. Petersburg, vol. III, p. 46, pl. II, fig. 1. Silurian.
6. Acritis, Volborth, 1869: Verh. Kais. russ. Mineralog. Ges., St. Petersburg, 2 ser., vol. IV, p. 212. Silurian.
7. Leptobolus, Hall, 1872: 24th Regent's Rep. New York State Mus. Nat. Hist., p. 226 (Perhaps identical with *Acritis*.)
8. Spondylobolus, M'Coy, 1852: Ann. and Mag. Nat. Hist., vol. VIII, p. 407. Cambrian, silurian.

All these numerous genera are of almost exclusively silurian distribution, and it must appear somewhat strange that this family should be rather largely represented in the Salt-range in beds that cannot be very far distant in age from the true Productus-limestone, which is according to the most probable deductions that can now be drawn, in its upper part at least not older than the magnesian-limestone or the permian of Europe, and in its lower division does not exceed in age the uppermost coal-measures of North America. According to what has been said on pages 6-8 of this volume, the age of these "*Obolus*" bearing beds can then barely be more than that of the lower-carboniferous. A circumstance which makes these deductions probable also from a palæontological point of view is, that although forms agreeing in family characters with silurian shells are numerous, yet these deviate so far from the hitherto described silurian species, that not only they cannot be specifically identified with the latter, but all are even generically most decidedly distinct. And this is not only true within the family *Obolidæ*, but also in all the other families of the *Lyopomata*. Thus a considerable lapse of time must have occurred before *all* the forms could have been changed into differing generic groups; and the view that the beds in which these forms are found belong to the carboniferous period gains much in probability.

There are no obvious reasons why the *Obolidæ* and similar families should have become extinct after the silurian period, and nobody can deny the possibility of their having lived on somewhere on the globe after those times. So much the more must it be interesting to see them re-appear in the Salt-range in beds that are in more or less close connection with permian and upper-carboniferous strata, from which circumstance they may with much probability be taken as lower-carboniferous.

The *Obolidæ* of the Salt-range were detected about contemporaneously by Dr. H. Warth and Mr. Wynne, who both sent specimens for determination to Dr. Stoliczka at Calcutta. None of these specimens exhibited the inner surface, but as the outward appearance was very similar to that of *Obolus*, it was only natural that Dr. Stoliczka should have determined them to be *Oboli*, and the beds in which they occur to be silurian; an opinion in which I fully concurred at the time with my distinguished friend. On my return after a season's work in the Salt-range, I was no longer so firm in this opinion as before, as I had observed the close connection of the so-called

Obolus-beds with carboniferous strata, but the riddle of *Oboli* occurring apparently n more recent strata than silurian remained unsolved. Only after having received the Salt-range materials in Europe, and after having compared the Indian specimens with Russian shells, was the riddle resolved, as I observed that the *Oboli* were no *Oboli*, the *Siphonotretæ* no *Siphonotretæ*, and so on; so that an entirely new fauna of *Lyopomata* slowly developed itself before me.

This result was, however, obtained only after much labour. The specimens always occur with their shells adhering firmly to a strongly micaceous rather hard slaty shale, and an internal cast is never to be found. At last I fastened the shells by their outerside with Canada balsam to glass slides, and was then able with chisels to clear the inner side from the adhering rock. Owing to the extreme thinness of the shells it may be imagined that the operation was most difficult and tedious, and it may be excused that the results are not so complete as could be desired. The muscular impressions were for the most part obliterated, and my indications in this direction must be rather uncertain. But the forms have been found to contain features of a firmer structure, as septa, etc., so that a generic determination could well be made without an intimate knowledge of the muscular impressions. Better results may be obtained when specimens freshly taken from the rock *in situ* can be operated upon, as then the rock is much less hard, and less firmly adhering.

I thus came at last to learn that the so-called *Oboli* of the Salt-range belonged chiefly to two different forms, one rather nearly related to the genus *Obolus*, but yet easily distinguishable, the other very widely deviating, and probably not belonging even to the family, but rather to the *Trimerellidæ*, in which it might be placed near the *Dinobolus*.

The form which I shall retain in the family *Obolidæ* is characterised by a large septum in the dorsal valve; it will bear the name of *Neobolus*, Waagen.

Genus: NEOBOLUS, Waagen, n. gen.

This genus consists of rather small shells, with a roundish outline, and not quite equal valves, the ventral one being generally protracted into a little beak with a furrow on its underside, while the other has only a somewhat thickened cardinal margin. Both are equally arched, but very slightly. The substance of the valves is very thin, horny, calcareous.

The interior of both valves is tolerably well known to me; only the muscular impressions are somewhat doubtful, as in chipping out the stony matter the innermost coating layer of the shell substance also very often splits off, and then the muscular impressions, which are always rather faint, are more or less obliterated.

In the ventral valve the cardinal margin is not much thickened, and is interrupted in the middle by a rather broad, transversely striated furrow, which served for the insertion of the peduncle. Inside this furrow in the depth of the valve, laterally from the middle line, there are apparently two small muscular impressions,

probably of one pair of adductors. The other pair of adductors seems to have left its impressions about in the middle of the valve, just above a short thickened ridge or knob which occurs there; but the two impressions that exist in Obolus are here apparently combined into one. On the lateral parts of the valve there are two pairs of very large impressions, of which one partly covers the other; which, if any, of these are muscular impressions, cannot be decided; they must in such case be the impressions of the divaricators.

In the dorsal valve the cardinal margin is arched and very little thickened, except in the middle, where a strong, thick callosity of a somewhat triangular shape is situated, bearing on top a somewhat uneven platform, which apparently served for the insertion of the muscle of the peduncle (umbonal muscle?). This callosity is prolonged towards the interior of the valve into a strong median septum, which sometimes takes its origin immediately at the callosity, sometimes at a little distance from it, and extends to not far from the front of the valve. Of muscular impressions but very little can be seen in this valve. Along the lateral margins a pair of large elongated impressions extend; they may perhaps be taken as the impressions of the divaricators. In the corner between these and the cardinal margin another pair of impressions seems to occur, but very indistinctly. Of the median pair of adductors nothing can be distinguished. Besides the muscular impressions and the septum, there are in both valves some more or less strongly developed radiating lines, slightly raised, the meaning of which I do not apprehend.

These are the characters of the genus; and it appears obvious that shells bearing these characters cannot belong to the genus *Obolus*. The characters of the genus *Obolus* have been admirably illustrated by Davidson, Quenstedt, Zittel,[1] etc.

We can now compare the Indian shells with *Obolus*. As regards the larger or ventral valve, we find that the cardinal margin is considerably thickened; the furrow for the passage of the peduncle is not very broad, and from the inner side of it a strong median septum projects and reaches down to about the middle of the valve. Of the adductor impressions one pair is situated in the corners between the septum and the cardinal margin, and the other on both sides of the median termination of the septum. All these are characters in which the Russian shells deviate from our *Neobolus*. The latter has a very little thickened cardinal margin and not a trace of a septum, and also the muscular impressions seem to be differently arranged.

In the dorsal valve also, *Obolus* presents a very strongly thickened semi-lunar cardinal margin, which sometimes bears a slight indication of a furrow in the middle. One pair of the adductor impressions is situated immediately below this margin, laterally from the middle line; the other pair is to be found about in the middle

[1] In Zittel's Handbook an error occurs, which might be misleading. On p. 664 of vol. I there is a woodcut of *Obolus*, which is said to represent the interiors of both valves and an exterior view of the smaller one. Now, fig. d, which is stated to be the interior view of the smaller or dorsal valve, is in fact a representation of the interior of the larger or ventral valve, copied from Quenstedt's Petrefactenkunde Deutschland's vol. II, pl. 61, fig. 12. There has evidently been a mistake by the artist, who copied this figure instead the one immediately at the side of it (fig. 13) representing the interior of the smaller or dorsal valve.

of the valve, but rather distant from the middle line, leaving a broad smooth space between them. There is not a trace of a septum in this valve. In *Neobolus* the dorsal valve has a thin cardinal margin, provided in the middle with a thick triangular callosity, from which starts a strong septum reaching to near the front.

The differences thus indicated are quite sufficient to distinguish between the two genera.

Of other genera of the *Obolidæ* only *Schmidtia*, Volborth, might perhaps be compared, as in this genus also there is in the dorsal valve a slightly raised middle line, perhaps comparable to a septum. This genus, however, presents in the ventral valve a large area with a deep furrow on it, which is totally wanting in *Neobolus*.

The genus is entirely restricted to the Salt-range, and occurs there exclusively in those beds which received from Wynne the name of *Obolus* beds. I can distinguish among the materials at my disposal two different species of the genus, which will receive the names of *Neob. warthi* and *Neob. wynnei*, in honour of the two first discoverers of these shells.

1. Neobolus Warthi, Waagen, n. gen. et sp.; Pl. LXXXIV, figs. 3, 4, 5, 6, 7, 8.

1878. *Obolus*, sp. (Stoliczka) Wynne: Geology of the Salt-range: Mem. Geol. Surv. of India, vol. XIV, pp. 68, 87, *et passim*.

The general outline of this species is rather difficult to determine, as most of the specimens are greatly deformed by pressure. On the whole, however, the outline seems to have been about transversely oval, the ventral valve with a slightly prominent beak, and the dorsal one with a rounded cardinal margin. Both valves are very flat, but the actual form of their curvature is barely possible to determine on account of the deformation the specimens have undergone. The surface of the valves is perfectly smooth.

The ventral valve seems to vary somewhat in outline, which is sometimes well and equally rounded on all sides, only the apex being slightly prominent; sometimes, however, there is a distinct cardinal margin developed, which joins the lateral margins of the valve under obtuse angles, and ascends from both sides towards the apex. In the former variety the greatest breadth of the valve occurs mostly in the middle, in the other variety it is to be found more towards the front. As regards the curvature of this valve, it seems to be generally even flatter than the other, having barely any depth at all.

The dorsal valve shows quite the same variations in outline as the other one; but in this valve the form with a well-marked cardinal margin is more frequent than in the other. In this variety the cardinal margin forms an arched line, which joins the lateral margins under obtuse angles; the lateral margins are rather straight and then curve somewhat abruptly round to the well-arched front margin. In the other variety the cardinal margin is also slightly marked off, but the angles under which it joins the lateral margins are so very obtuse as to be almost imperceptible.

The lateral margins are well rounded, and unite imperceptibly with the frontal one. This valve is generally about twice as deep as the other one, and its curvature seems, as far as can be observed, very regular in every direction. The apex is barely perceptible, not prominent, and chiefly marked only by the arrangement of the striæ of growth.

The surface in both valves is smooth and shining, covered with very numerous faint striæ of growth parallel to the frontal and lateral margins and curved round the apex.

The substance of the valves is very thin and often has the ashy-blue colour of vivianite, a circumstance indicating the presence of phosphorus in their composition.

The interior characters of both valves have been represented in detail in the description of the genus.

In the much-deformed state of these shells it is rather difficult to make exact measurements, yet I shall give some indications at least as to the largest ventral (No. I) and the largest dorsal valve (No. II) known to me. The measurements are as follow :—

	I.	II.
Entire length	10 mm.	9 mm.
„ breadth	11 „	10 „
Thickness	1 „	2 „

No specimen has been found with both valves adhering.

Locality and geological position.—This is the most common species of the so-called *Obolus* beds of the Salt-range. It occurs in these beds by hundreds, but the localities where it has been found are not numerous. At Khewra it is very abundant, in the gorge above the salt-mines, not far from the place where the fresh-water springs are situated. A small slab of shale, figured on Plate LXXXIV, contains not less than five complete specimens with fragments of several others. Another locality where the species also occurs, but less numerously, is Jutána. Chel hill has also yielded some fragments which perhaps belong to this species.

Remarks.—The present species is, in its outward appearance, chiefly comparable to *Obolus apollinis*, Eichw. Not to speak, however, of the internal differences, it is easily distinguishable from the Russian species by its smaller size and much thinner shell-substance.

Another shell, which is in fact very nearly related to the present one, is *Neob. wynnei*, Waagen, to be described next, from which the species under description is distinguishable by its smooth outer shell-surface, which is concentrically ribbed in *Neob. wynnei*.

2. Neobolus wynnei, Waagen, n. gen. et sp.; Pl. LXXXV, figs. 1, 2.

This is an extremely pretty little shell, but rather rare. Its general outline is very strongly oval transversely. The two valves are not very different, flat, extremely thin, and having a very fine concentric sculpture on the outer surface.

The ventral valve is slightly larger than the dorsal one, nearly quite flat, only slightly elevated in the apical region. The apex is pointed and well prominent, but not bent over. From the apex the cardinal margin, which is very distinctly marked off, slopes towards both sides, and meets the lateral margins under obtuse angles. The greatest breadth of the shell is situated not far from the front, and as the cardinal border is much shorter, the lateral margins must strongly diverge, but otherwise they are nearly straight, not much curved; not far from the front they bend suddenly round and unite with the flatly arched frontal margin. The surface of this valve is covered with numerous well-marked striæ of growth, between which an extremely fine concentric sculpturing may be seen, but only with a strong lens and under favourable conditions. This sculpturing consists of very closely arranged, fine, erect lamellæ extending parallel to the frontal and lateral margins.

The dorsal valve is somewhat smaller than the ventral one. It is slightly arched in the longitudinal as well as in the transverse direction, and is most elevated about the middle. The cardinal margin is distinctly marked off and nearly straight. The apex is depressed, not prominent, and on the whole barely at all developed. The greatest breadth of the valve is placed far down towards the front, and thus the lateral margins are rather strongly diverging. They unite with the cardinal border under an obtuse angle and are not much curved; after a rather sudden bend they join the frontal margin, which is very flatly arched. The sculpturing of this valve is very similar to that of the other one, only that the striæ of growth are much less strongly marked. Of the interior characters of this species little is known. In the dorsal valve a callosity below the apex and traces of a median septum can apparently be observed shining through the very thin semi-transparent shell, but of the interior of the ventral valve nothing at all is known to me.

The dimensions of two specimens, No. I, a ventral valve from Jutána, and No. II, a dorsal valve from Khewra, are as follow :—

	I.	II.
Entire length	6·5 mm.	6 mm.
„ breadth	9 „	10 „
Length of the cardinal margin	7·5 „	7 „
Entire thickness	1 „	1·5 „

Locality and geological position.—This species is much rarer than the preceding one; this may, however, to a great extent be due to the state of preservation. The very fine sculpturing which distinguishes this species from the other is easily destroyed, and then it is very difficult to recognise the present form. It has been found at Khewra as well as at Jutána, but at both places only sporadic specimens occur, and there are barely any that I could with certainty assign to the present species except the two figured specimens.

Remarks.—It has already been mentioned that the present species is distinguishable from *Neobolus warthi*, W., by its surface sculpturing. That this is in reality absent in the last-mentioned species, is shown by several specimens, in which,

even under a very strong magnifying power, the shell-surface appears shining smooth, with occasional very fine striæ of growth, whilst in *Neobolus wynnei* this surface is quite different.

Family: TRIMERELLIDÆ.

This is one of the best described families existing, and the admirable paper by Davidson and King on these fossils will always be considered a standard work.

It seems unnecessary to repeat here the very complicated family characters, the most striking of which is the existence of a platform in both valves, mostly vaulted and hollowed below, on which the muscular impressions are in part situated.

The genera belonging to the family are not very numerous; and there is considerable agreement between different authors as to the genera which ought to be considered as belonging to the family.

Davidson in the last part of his British Fossil Brachiopoda quotes the following genera:—

1. Trimerella, Billings, 1862: Geol. Surv. of Canada, Palæontology, p. 166, vol. I, fig. 151, a. b.
2. Monomerella, Billings, 1871: Canadian Naturalist, new ser., vol. VI, p. 220.
3. Rhynobolus, Hall, 1871: 23rd Regent's Rep. New York State Mus. Nat. Hist., p. 247, pl. 13, fig. 10. This genus has by most authors been considered identical with *Trimerella*; and also Davidson and King in their paper on the family place the type-species *Rhyn. galtensis*, though with a query, in the genus *Trimerella*. Recently Mr. Davidson seems to have given up this view, in which I perfectly concur with him. *Rhynobolus* seems to me a well distinguishable genus, holding about the middle between *Trimerella* and *Monomerella*, with some characters reminding also of *Dinobolus*.
4. Dinobolus, Hall, 1871: 23rd Regent's Rep. New York State Mus. Nat. Hist., p. 247.

All these genera are of an exclusively silurian distribution.

To these has to be added yet one more genus from the Salt-range, for which I shall introduce the name of *Davidsonella*. This genus appears to be somewhat related to *Dinobolus*, yet deviating from it very much. That it belongs to the family, there can be, it seems to me, but very little doubt, though the shell-substance is very thin. The platform in the middle of both valves is so distinct, and in the ventral valve at least so similar to that of *Dinobolus*, that the family cannot be mistaken.

There arises, however, the same difficulty with regard to this genus that has been discussed already with regard to *Neobolus*. The beds in which the *Davidsonellæ* occur in the Salt-range can barely be older than lower-carboniferous, and we have again a most remarkable re-apparition of the family. The long interval of time from the silurian up to the lower-carboniferous would find an adequate expression in the far deviating generic characters of the Indian shells.

Genus: DAVIDSONELLA, Waagen, n. gen.

I create this name in honour of Mr. Davidson, the greatest living authority on Brachiopoda, in order to express once more the great admiration I feel for his unrivalled works. Though his name has been already once connected with a genus of Brachiopod, yet it is appropriate that it should also be perpetuated within the family of *Trimerellidæ* as being one of the most interesting groups of Brachiopoda.

This genus, in comparison with the other genera contained in the family, is composed of shells of a very small size, and the substance of these shells is extremely thin and fragile, in which respect also it differs from other genera of the *Trimerellidæ*.

The general outline of these fossils is more or less linguloid, longer than wide, or to a certain extent transversely trapezoidal. Both valves are slightly vaulted, but the ventral one generally more so than the dorsal. At the same time the ventral valve is also larger, and possesses a prominent apex, which is provided on its lower surface with a deep furrow for the insertion of the peduncle.

Of the internal characters of the genus the general features are well known to me, but the details are yet far from being completely ascertained.

In the ventral valve the cardinal margin is somewhat thickened, but not sufficiently so to distinguish an area or a pseudodeltidium. The furrow in the middle is very deep. Below there extends a not very large triangular platform, hollowed out underneath, and supported in the middle by a low partition; this does not, however, extend beyond the platform, so that no septum is visible. This platform is shut in on both sides by low but distinct rounded ridges. These ridges originate below the cardinal margin on both sides of the peduncular furrow, and diverge thence under an acute angle. They descend in a nearly straight line, as far as the platform extends, and then proceeding further in the direction of the frontal margin bend slowly round towards the middle line of the valve. The platform itself is not quite intactly preserved, as its frontal edge is broken, and thus the exact shape of this organ cannot be ascertained. In the middle of it, from near the peduncular furrow to the lower margin, a narrow flat space extends, hemmed in on both sides by narrow furrows. This space probably served, in part at least, for the insertion of muscles. The lateral parts of the platform are concave, instead of being vaulted as in *Trimerella;* yet they are not fastened to the body of the valve, an excavated space remains beneath them.

Of muscular impressions nothing can be observed. Two large deepened spaces along the lateral margins of the valve certainly cannot be taken as such. They have been drawn somewhat too distinctly by the draftsman, the general outline especially being too sharply marked. It seems to me that these deepened places are rather to be taken as the room outside the crescent, so that the somewhat raised inner margin of these impressions would represent a part of the crescent itself. From beneath the platform some fine, diverging, radiating raised lines proceed, the meaning of which

is unknown to me. The space outside the semi-circular ridges described above is very finely striated radially.

I am sorry that I am not in a position to describe the interior characters of this valve more accurately or to give a more exact figure of them, but in chipping off the stony matter from the inside minute particles of the valve are always removed at the same time, and thus the inner surface of the valve is at least so far deteriorated that while the general features can be well recognised the details are uncertain and unsatisfactory. This it is impossible to avoid; so that to arrive at any determination regarding these fossils, one must only make the most of the means available.

The internal characters of the dorsal valve are yet more strange than those of the other one. The cardinal margin is but little thickened and slightly curved. In the middle it bears a thickened shelly process very much resembling the prominent tooth in *Trimerella lindströmi*. This prominence is directed somewhat upward and inward, and must have extended partly into the apical cavity of the other valve. From beneath this process a short thickened platform takes its origin; it is not even on top, but to all appearance spirally enrolled. It is concave in the middle and bears on both sides elevated crests with sloping lateral faces. The frontal margin of it is curved inwards, but the whole platform seems to be excavated below, not solid. From its lateral faces there start strongly diverging elevated ridges which divide into two a very short way from their origin. A median septum, which is low at the beginning and highest at its termination not far from the frontal margin, proceeds from under the platform. From both ends of the cardinal margin elevated ridges take their origin; starting at right angles from that margin, they bend again out towards the lateral margins of the valve. Outside of these ridges deepened spaces are to be observed, which probably correspond to the similarly placed deepened spaces of the other valve.

In this valve also muscular impressions are not observable, unless the median impressions on the tooth-like process are to be taken as the scars of the cardinal muscles.

Such are the characters observed in the two valves. If we make allowance for any error due to the bad preservation of the shells, there would still remain the undoubted facts that there is a platform in both valves, and a cardinal tooth and a median septum in the dorsal one, and that the shape of these organs in both valves is quite certain.

But if these points can be taken as well ascertained, the systematic position of the genus can no longer be doubtful. The platform of the ventral valve very much resembles in shape the corresponding part of *Dinobolus*, and the median tooth-like process in the dorsal valve may be exactly compared to the same organ of *Trimerella lindströmi*. If these parts are exactly similar, the remaining organs may at least be typically compared with similar parts in the *Trimerellidæ;* thus there remains for me not the slightest doubt that the genus must be placed in that family.

From the other genera of the family the present one is, however, rather divergent. Already the very thin shell-substance is a character which does not generally occur in the *Trimerellidæ*, except perhaps in *Dinobolus*. The interior characters of

the ventral valve can also be best compared with those of *Dinobolus*, though only in a general way and not in detail. The internal features of the dorsal valve are quite peculiar, and, with the exception of the tooth-like process below the cardinal margin, not like anything hitherto described in the *Trimerellidæ*, though on the whole comparable in type to *Trimerella lindströmi;* it thus appears that the genus *Davidsonella* unites characters which are in other cases distributed between *Dinobolus* and *Trimerella*.

Thus the observation recorded above, that the great difference of genera in the "*Obolus* bed" of the Salt-range from those contained in the silurian *Obolus*-bearing strata, indicates the very long time that must have elapsed between the formation of the two deposits, is true also in this case. The difference of *Davidsonella* from the remainder of the genera of the *Trimerellidæ* appears even greater than the differences of these from each other; so that in this case also it is clearly indicated that the Salt-range *Obolus* bed is much more recent than silurian,—a fact that is also borne out by the geological data, as described above (p. 8).

The genus is represented in the Salt-range by two species, which will bear the respective names of *Davidsonella linguloides*, W., and *Davids. squama*, W. Of these the first is not very rare, but the second has been detected up to the present only in one or two specimens.

1. DAVIDSONELLA LINGULOIDES, Waagen, n. gen. et sp.; Pl. LXXXV, figs. 3, 4, 5, 6.

The general outline of this species is mostly linguloid, somewhat longer than wide, the greatest breadth being situated about in the middle of the valves. The two valves are different in size, the ventral one longer with a pointed apex, and the dorsal shorter. Both are about equally vaulted, but never very strongly. The external surface is smooth, with the exception of very fine and very closely set striæ of growth.

The ventral valve is flatly but very regularly vaulted. The margins are rather flatly spread out; thence the valve rises gradually towards the apical region, which is the most elevated part of the valve. This elevation, however, does not exceed 1 millimeter. The outline of the valve is elongately oval, with a distinctly defined cardinal border. The apex is marginal, and the cardinal margin forms a broken line, the most prominent point coinciding with the apex; it unites with the lateral margins under distinctly obtuse angles. The latter present regular flat curves, and unite gradually with the equally well rounded frontal margin. The apex is prominent, and provided on its lower side with a narrow, no very distinct area, which bears in the middle a very deep but not broad furrow for the insertion of the peduncle. Of the internal features the most conspicuous are the curved ribs which start from below the apex, and apparently surround the visceral part of the valve. That the lateral impressions have been incorrectly represented in fig. 6, on pl. LXXXV, has been noticed already in the description of the genus. The representation in the enlarged figure (fig. 3*b*) is more correct.

The dorsal valve is a little less strongly vaulted than the ventral one, but its curve is also very regular. In this valve, however, the apex is not the most elevated part; the greatest elevation is situated at a certain distance from the apex, more near the middle of the valve. The outline of the valve is very regularly rounded with the exception of the cardinal border, which is nearly quite straight, only very slightly arched, and much shorter than the greatest breadth of the valve; it joins the lateral margins under obtuse angles. All the remainder of the outline forms a regularly curved line, there being no demarcation between the lateral and frontal margins. The apex is only marked by the arrangement of the very numerous fine striæ of growth; it is not prominent in any way. It is quite marginal, situated immediately at the cardinal border.

The interior characters of this valve have been discussed in detail in the description of the genus.

The substance of the shell is very thin. With the exception of the numerous striæ of growth the shell seems to be quite smooth, and I cannot detect either punctures or granulations.

As to size, the present species is one of the most conspicuous shells contained in the so-called "*Obolus* beds," though the form shows very moderate dimensions in comparison with other *Trimerellidæ*. The measurements of two specimens from Jutána (No. I, a ventral and No. II, a dorsal valve) are as follow:—

	I.	II.
Entire length of the shell	12 mm.	8·5 mm.
„ breadth of the shell	11 „	9 „
Length of the cardinal border	7 „	6 „
Thickness of the valve	1·25 „	0·75 „

The dimensions are, however, very variable, as these shells are, like all the others occurring in the same beds, subject very much to deformations by pressure.

Locality and geological position.—There are several reasons why it appears very difficult to give numerical indications as to the frequency of this species. As has just been stated, these shells are very much subject to deformations by pressure, and then the general outline cannot be made use of for the determination of specimens in which the interior characters are not visible. These latter are, however, extremely rare, and thus the evidence of the occurrence of the species at different localities is very scanty. It would seem that the species was not rare in the "*Obolus* beds" at Jutána; but, as the determinations were mostly taken only from the outward appearance of the fossils, they cannot be entirely relied upon. So much, however, is certain, that the species is apparently much more rare or even nearly absent at Khewra, above the salt-mines.

Remarks.—There is no species to which the present one could be more particularly compared. That the species belongs to the *Trimerellidæ* is, I think, not very doubtful. The deviation from other forms of the same family is, however, very complete, and indicates again the very long space of time which must have elapsed since the existence of the silurian Trimerellids. Already in *Neobolus* we had only

dwarfed forms of the silurian types. This pygmean condition is still more conspicuous in the species of *Davidsonella*. It is not only that the size, which is very conspicuous in the silurian *Trimerellidæ*, has dwindled down to an absolute insignificance but also the solid, or even ponderous, shell of the silurian species has been changed into one of the thinness of paper. The shell thus becomes in outward appearance very similar to *Lingula*—a fact which recalls very much certain cases of atavism; the *Trimerellidæ* beyond doubt took their origin from Lingula, and here we see them return again in their outward appearance to that genus during the last stages of their existence.

2. DAVIDSONELLA SQUAMA, Waagen, n. gen. et sp.; Pl. LXXXVI, fig. 1.

This is a very rare species. Its general outline is somewhat trapezoidal, with a broadly rounded front and a very short indistinctly defined cardinal border. The shell surface is smooth, with a slightly indicated radial folding.

The ventral valve, the only one that is known to me, is nearly quite flat, but very little vaulted, though this flatness may partly be due also to a compression the shell has sustained. The cardinal border is very short and arched, passing gradually into the straight lateral margins. These diverge very strongly and, after a certain distance, bend round to join the rather flatly and broadly curved frontal margin. The apex is but little prominent, pointed, and overhangs slightly the cardinal border.

The surface of the shell is ornamented with many not very sharply developed striæ of growth, crossed by a very faint radial plication, which is chiefly observable at the lateral parts of the valve, being entirely absent in the middle. It consists of broad flattened folds, separated by narrow furrows. With a powerful lens an extremely fine concentric striation can be observed.

Of the interior characters of the shell very little is known to me, as it seemed impossible to expose the inner surface. In the specimen at my disposal there can, however, be seen through the thin shell the two curved ribs which enclose between them the visceral part of the shell, and which are characteristic of the ventral valve of *Davidsonella*.

Other parts, which also are slightly indicated on the outside of the shell by a difference of shading, cannot be made out as to shape, etc., and therefore cannot be identified.

The species is one of the largest occurring in the "*Obolus* beds" of the Salt-range, and the measurements of the single existing specimen, a ventral valve, are as follow:—

Entire length of the valve	13 mm.
„ breadth „ „	14·5 „
Approximate length of the cardinal border	5·5 „
Thickness of the valve	1 „

Locality and geological position.—This species was originally represented by two specimens in the Salt-range collection, both ventral valves only, but unfortu-

nately one of them was broken in trying to expose the inner surface. Both specimens were found by Mr. Wynne in the so-called *Obolus* beds at Jutána.

Remarks.—The present species is very nearly related to the preceding one, but can easily be distinguished by its very short and indistinct cardinal border, and little prominent apex.

That the species belongs to the genus *Davidsonella* cannot be subject to any doubt; though I have not succeeded in cleaning the interior surface of one of the specimens, yet what can be seen shining through the shell-substance is sufficient for the determination of the genus.

Family: *LINGULIDÆ.*

This is the most long-lived family among all the molluscs and molluscoids, as the well-known oldest forms of organised beings belong to this family, and from the very dawn of organic life it extends through all the periods up to recent times.

Though it is to be supposed that in this extremely extended period of existence the family must have been exposed to the most varied outward conditions ever experienced by single forms of organic life, yet the range of variability within the family is smaller than in most other families, and in *Lingula* itself even the generic characters have been retained through all the stretch of time from the silurian to the present period. This is one of the strongest facts that have been brought to the notice of biologists, and one which evolutionists are absolutely at a loss to explain. It very strongly suggests the notion that the real reasons for the variation and evolution of organisms are yet far from being known to us, and that, though the outward conditions may have a great influence, yet they are certainly not the sole reason and cause for the variation of animals, as certainly as the "survival of the fittest" is not the sole reason for the persistency of certain variations. Else we must be prepared to admit that *Lingula* is one of the "fittest" animals that ever was produced, as under all the changes of conditions that it had to endure, it survived thousands and millions of other beings which had apparently a far greater ability to adapt themselves to changed circumstances.

Howsoever this may be, the family comprises a very compact little group of forms, which are rather with difficulty distinguishable from each other. Davidson, in the last part of the British Fossil Brachiopoda, admits the following genera in the family:—

1. Lingula, Bruguière, 1792: Encycl. Méthod. I, pl. 250. Silurian to recent.
2. Lingulella, Salter, 1866: Mem. Geol. Surv. Great Brit., vol. III, p. 333. Cambrian.
3. Lingulepis, Hall, 1863: 16th Rep. Regent's State Cab. Nat. Hist. New York, p. 129, pl. VI, figs. 15-16. Cambrian.
4. Glottidia, Dall, 1870: Amer. Journ. of Conchol., vol. VI, p. 157, pl. VIII, figs. 1-6. Recent.
5. Glossina, Phillips, 1848: Mem. Geol. Surv. Great Brit., vol. II, p. 370. Cambrian, silurian.
6. Dignomia, Hall, 1871: 23rd Rep. Regent's State Cab. Nat. Hist. New York, p. 245, pl. XIII, fig. 3. Silurian.
7. Lingulops, Hall, 1871: 23rd Rep. Regent's State Cab. Nat. Hist. New York, p. 245, pl. XIII, figs. 1-2. Silurian.

One sees from this list that by far the greater part of the genera lived during cambrian and silurian times, whilst in the mesozoic and cainozoic formations only the genus *Lingula* existed, and to that genus only the genus *Glottidia* is added in the present period. From this it appears that the variability of the shells belonging to the genus was by far greater in the most remote periods than later.

I regret to say that I am not in a position to add much to the knowledge of this family from observations made on the materials from the Salt-range. There are amongst them some shells which possibly might belong to the genus *Lingula*, but they are extremely rare, and this scarcity prevented me from studying the inside of these shells, so that their determination as *Lingulæ* must be accepted with great caution. But as there is as little to suggest that they might belong to any other genus, I place them provisionally with Lingula.

There are two different forms which I associate with *Lingula*, but each of them might belong even to a different genus, as one possesses a kind of cardinal border, while the other has none; but, as I know nothing of the interior, they may as well both stand in the genus *Lingula*.

Genus: LINGULA, Bruguière.

The outward appearance of this genus is very characteristic. The shells are nearly always smooth, elongately oval, with not quite equal valves, the ventral one somewhat larger, with a small area, and the dorsal one smaller, but also provided with a kind of very small area, for the insertion of the peduncle. Both valves are rather flat, but very little vaulted.

These outer characters are very characteristically exhibited by two shells occurring in the "*Obolus* beds" of the Salt-range; and chiefly their very elongated oval shape causes me to consider them as *Lingulæ*.

Of the interior characters of these shells nothing is known to me; so the determination must remain doubtful.

Though only two specimens are available, yet they must be attributed to two different species, as one has an entirely smooth shell, and the other slight indications of a radial folding. Both are very small, and in this respect they both recall rather the carboniferous and permian species than the large Lingulæ of more ancient formations.

1. Lingula kiurensis, Waagen, n. sp.; Pl. LXXXVI, fig. 8.

The general outline of this species is strongly elongately oval, with a rather distinctly defined cardinal border, which is considerably shorter than the greatest breadth of the shell.

The ventral valve, the only one known to me, is very flatly but very equally vaulted. The most elevated part is, however, not at the apex, but a little removed from it, somewhat more towards the middle of the valve. The apex is entirely marginal, prominent, pointed, and overhanging the cardinal border. The cardinal

margin forms sloping straight lines on both sides of the apex, which join the lateral margins under not very sharply defined obtuse angles. The lateral margins are rather strongly diverging, and but very little curved, nearly straight. After a certain distance they bend slowly round and join the semi-circular frontal margin.

The surface of the shell is quite smooth, only provided with tolerably numerous obtuse striæ of growth.

Of the interior characters of the dorsal valve as little is known to me as of its shape and characters.

The dimensions of the single existing specimen are as follow:—

Entire length of the shell	9·5 mm.
„ breadth „	7 „
Length of the cardinal border	4 „
Thickness of the shell	1·5 „

Locality and geological position.—The only existing specimen of this species was collected by myself at Khewra above the salt-mines, not far from the fresh-water springs, in the so-called *Obolus* bed.

Remarks.—In size the present species appears to be rather nearly related to *Lingula mytiloides*, Sow., from the carboniferous-limestone, or *Lingula credneri*, Gein., from the permian formation. The former especially has in its general outline a certain similarity, in as much as the greatest breadth of the shell is shifted from the middle more towards the front, but the Indian form is altogether broader, and not so much elongated as the English species.

There is no other species with which the present one could be more particularly compared.

2. Lingula warthi, Waagen, n. sp.; Pl. LXXXVI, fig. 9.

This species is rather regularly elongate-oval, without a demarcated cardinal border. Besides this, it is characterised by a not very distinct radial plication.

I cannot decide whether the specimen from which this description is drawn up is a ventral or a dorsal valve.

The specimen is elongately oval, somewhat narrower in the apical than in the frontal region. The cardinal border is rather narrowly rounded, imperceptibly joining the lateral margins, which are diverging and nearly quite straight, only very little arched. The frontal margin is very flatly arched, but joins the lateral margins with a rather sudden bend. The whole valve is nearly quite flat, only very little vaulted. It is highest in the apical region. Not far from the apex a broad shallow sinus commences, and augmenting in breadth extends to not far from the frontal margin, but then disappears. The apex is rather obtuse, not prominent. On both sides of it thickened processes seem to extend interiorly, as can be seen through the transparent shell.

The surface of the shell is provided with few distant striæ of growth, which are crossed on the lateral parts of the shell by an irregular indistinct radial folding, producing an irregular reticulation of the shell surface.

Of the internal characters of this shell nothing is known to me.

The measurements of the only existing specimen are as follow :—

Entire length of the shell	8	mm.
Greatest breadth of the shell (not far from the front)	6·5	„
Breadth in the cardinal region	4	„
Entire thickness of the shell	1	„

Locality and geological position.—The only specimen of this species that has been found up to the present was collected by myself at Khewra above the salt-mines in the so-called " *Obolus* beds."

Remarks.—For a long time I was very much inclined to take this shell as the dorsal valve of the preceding species, but after a lengthened consideration I decided to consider it as a separate species. The chief reason which caused me to do so was the existence of a reticulation on the lateral parts of the present shell, a character which does not exist in *Ling. kiurensis*. It is not quite probable that the two valves of one and the same species should so far deviate from each other in the sculpturing, and, as the two specimens were not found in close proximity, to suggest their belonging to the same individual, I preferred to consider the two as different species.

I know of no European species with which the present one could be more closely compared.

Class: BRYOZOA sive CILIOPODA.

(By WILLIAM WAAGEN and JOSEPH PICHL, Assistant.)

Order: GYMNOLÆMATA.

Sub-order: CYCLOSTOMATA.

Family: *FENESTELLIDÆ.*

It has been an exceedingly difficult task to decide what should be considered as belonging to the *Bryozoa* and what not. With one group this decision has been comparatively easy, and this is the family *Fenestellidæ*, but with others it has not been so. It is well known that the *Chaetetidæ* and many other forms in connection with them have been considered by several authors, chiefly by Lindström and Zittel, as *Bryozoa;* and if these authors were right, a great many fossils occurring in the Salt-range would have had to be placed in this class. Already however Zittel was very doubtful as to the position of certain forms, as for instance of *Stenopora*, Lonsd., which also occurs plentifully in the Salt-range, but as these very forms are again most intimately connected with *Monticulipora* and allied genera, the position of these also must be questioned. It has now been possible to distinguish among the materials from the Salt-range a genus that will bear the name of *Dybowskia*, in which rudiments of two vertical radial septa exist, but which in all other respects agrees with *Monticulipora* and its congeners. There can be but little doubt that this new genus belongs to the corals, and from its intimate connection with other genera of tabulate corals, it appears highly probable that all the rest should be similarly placed. After this deduction there remained only two families of *Bryozoa* to be described here—the *Fenestellidæ* and the *Thamniscidæ*. There is no doubt that after careful search for the more minute creeping forms the number of families could be augmented, but for the present we must be contented to describe the larger most common and characteristic species.

It more especially regards the generic groupings of the family *Fenestellidæ* to remark, that most of the forms can easily be classed as soon as the two faces of the colony are known—the poriferous and the non-poriferous. This can however only rarely be achieved without much labour, as generally only one of the faces is naturally exposed, while the other adheres firmly to the supporting rock. It is usually the poriferous side which is thus concealed, as through the openings of the pores the rock-matter enters the interior of the colony, which thus becomes on that side most firmly attached to the rock. This circumstance is of not very material

importance when collections can be made at leisure; for, with time and patient search, the poriferous side of every species will be found incidentally exposed. But in a collection made in travelling, as was that of the Salt-range, such careful selection of specimens cannot be made, and thus in very many cases all the specimens of a species show only one side. It has now been the task of one of us to make up this defect of the materials at hand, and to prepare them so as to expose if possible in every specimen the two faces of the colony. This has entailed fully two years of labour, and only after this was it possible to attempt a full description of the *Bryozoa*.

It is well known that in the family *Fenestellidæ* the two sides of the colony are very different, on one side are the pores, that is to say, the entrances to the dwellings of the animals while the other side is devoid of pores, being occupied by the so-called basal-plate, on which the cells severally take their origin. The cells are mostly pyriform, which results from their commencing in a long thin point, widening slowly, and again contracting to form the pore or entrance. In this family they are arranged in three different ways: either they form two series, each turned laterally, the entrances thus forming pores opening on the two sides of the branches; or they originate in the middle and turn to all sides, except towards the basal-plate, pores being irregularly distributed over the whole obverse side of the branches; or lastly, the basal-plate sends a vertically protruding plate into the interior of the branches, and the cells originate on both sides of this plate, thus occupying two triangular spaces. The basal-plate requires some words of explanation: it is not, as would appear from some descriptions, the basal part or root of the whole colony; nor is it a separate shelly plate dividing the poriferous from the non-poriferous side of the colony; it is simply the shelly substance of which the non-poriferous side is made up. It is often very thin, so much so even that the cells can be seen through it, as on Plate LXXXVII, figs. 2*b*, 4*b*; or it may be much thicker, as in Plate XC, fig. 1*c*. In all cases the basal-plate is composed of very numerous longitudinally extended fine capillary tubes, and appears either as a sort of incrustation or as a thin shelly layer; it is mostly provided with very fine pores. Its surface is either finely striated longitudinally, or smooth, or provided with little tubercles.

Such is the finer or more intimate structure of the branches of the colonies as occurring in this family.

In close connection with this structure is the outward appearance of the branches, which is chiefly influenced by the arrangement of the cells, producing typical differences between the several forms. The first mode of arrangement indicated causes a median keel to be formed on the poriferous side of the branches, on each side of which the pores are situated. By the second mode, the poriferous side of the branches is strewn all over with pores, mostly arranged in quincunx, and a median keel never occurs. The third mode of growth appears only in few forms; they have a median keel on the poriferous side, as well as on the non-poriferous one, and are thus very characteristically distinct from the rest.

These typical differences between the several forms belonging to the family *Fenestellidæ* have apparently been already recognised, in part at least, by Claypole, who in a recent paper read before the Geological Society of London brings certain forms of the *Fenestellidæ* into a more intimate connection, while excluding others from consideration. At the same time however he neglects a character which is of equal or even greater importance than the intimate structure of the branches; this is the existence of fenestrules. This character is the distinguishing one between the families *Fenestellidæ* and *Thamniscidæ*. Thus we cannot agree with Claypole in bringing the genera *Glauconome* and *Ichthyorhachis* into more close connection with *Fenestella* and the rest; we shall in accordance with Zittel's Hand-book place these genera in the family *Thamniscidæ*, but for the rest of the genera adduced by Mr. Claypole, we perfectly agree with that author in bringing them more closely together. This can however be done most simply, as in other parts of this work, by creating sub-families for the group of forms pointed out by Claypole as well as for the other typically deviating groups pointed out above. We thus come to create three sub-families—the *Fenestellinæ*, the *Polyporinæ*, and the *Goniocladinæ*.

Sub-family: *FENESTELLINÆ.*

All the genera belonging to this sub-family show colonies which form leaf-shaped reticulated expansions, either with a median axis and lateral branches, or with two lateral axes, or with one lateral axis, round which the expansion is spirally rolled up, or at last without axis at all, only fastened to the ground by a kind of root or thickened part. In all these differently shaped colonies the branches on the cell- or pore-bearing surface are provided in the middle with a prominent keel, on each side of which the cells are arranged in regular rows. The dissepiments by which the branches are connected are mostly without cells.

The genera belonging to this sub-family are the following:—

1. Fenestella, Lonsdale, 1839: Murch. Sil. Syst., pl. 15. The colony is fan-shaped or infundibuliform, without a marked axis; the pores are generally on the upper or interior side of the funnel; there is one row of pores on each side of the median keel on the branches. Silurian to permian.
2. Fenestralia, Prout, 1858: Transact. Acad. Sci. St. Louis, Vol. I, p. 235, pl. 15, fig. 1. Colony similar in shape to the preceding, but two rows of cells or pores on each side of the median keel on the branches; the keel extending to the dissepiments, but not the pores. Carboniferous.
3. Septopora, Prout, 1859: Transact. Acad. Sci. St. Louis., Vol. I, p. 448, pl. 18, fig. 2. Colony similar in shape to the preceding and agreeing with *Fenestella* with the sole distinction that the dissepiments also are poriferous. Carboniferous to ? permian (*Synocladia biserialis*, Swallow).
4. Lyropora, Hall, 1857: Proc. Am. Assoc. Adv. of Sci., Vol. 10. Colony supported on both sides by strong stony axes diverging from the base between which the reticulated part is spread out; the arrangement of the pores as in *Fenestella*. Carboniferous.

5. Ptilopora, M'Coy, 1844: Synops. Carb. Foss. Ireland, p. 199-200, pl. 28. Colony flabelliform, with a strong median axis, from which rise on both sides branches that are connected by dissepiments; arrangement of the pores as in *Fenestella*. Carboniferous.
6. Helicopora, Claypole, 1883: Quart. Journ. Geol. Soc. Lond., Vol. XXXIX, p. 32, pl. IV. Colony flabelliform, turned spirally round an imaginary axis; the arrangement of the cells as in *Fenestella*. Silurian.
7. Archimedes, Lesueur, 1842: American Journ. of Sci. & Arts; Hall 1858, Palæont. of Iowa, p. 651. Colony flabelliform, turned spirally round a thick strong axis; the arrangement of the cells as in *Fenestella*. Carboniferous.

Other genera like *Disticheia*, Sharpe, *Carinopora*, Nicholson, *Cryptopora*, Nicholson, &c., might also belong to the present sub-family, but we are not sure on this point.

As will be seen from this list, the sub-family *Fenestellinæ* is of a chiefly carboniferous distribution, though the genus *Fenestella* begins in the silurian and extends to the permian period, and the genus *Helicopora* is exclusively upper-silurian.

In the Salt-range only the genus *Fenestella* occurs, and is represented there by two (perhaps three) species.

Sub-family: *POLYPORINÆ*.

The shape of the colonies occurring in the genera belonging to this sub-family is much less varied than in the preceding sub-family. Most of the genera have fan-shaped or infundibuliform colonies while only in exceptional cases a median axis occurs. The number of genera is also much less, whereby the smaller range of variation may be explained. The chief character of the family consists in the circumstance that the branches are covered all over with pores on one side, an arrangement depending, as has been explained above, on the internal structure of these parts. The genera belonging to this sub-family are the following:—

1. Polypora, M'Coy, 1844: Synops. Carb. Foss. Ireland, p. 206. Colony fan- or funnel-shaped; the pores restricted to the branches and absent on the dissepiments. Silurian to permian.
2. Phyllopora, King, 1849: Monogr. Brit. Perm. Foss., p. 40. Colony fan- or funnel-shaped; the branches as well as the dissepiments covered with pores; dissepiments and branches of equal thickness. Silurian to permian.
3. Synocladia, King, 1849: Monogr. Brit. Perm. Foss., p. 38. Colony fan- or funnel-shaped; the branches and dissepiments covered with pores; dissepiments angularly bent. Permian.
4. Dendricopora, Koninck, 1876-77: Rech. sur les Foss. paléoz. de la Nouv. Galles du Sud, 3me partie, p. 169, pl. VIII, fig. 4. Colony dendritic with a strong median and several lateral axes, dissepiments very thin; obverse of the branches with three rows of pores. Carboniferous.

To these should be added the genus *Protoretepora*, Kon.; but it seems that this name should be better considered as only a synonym of *Polypora;* the sole

difference between the two consisting in the circumstance, that in the one the pores are said to be placed on the inner, in the other on the outer side of the funnel-shaped colony. Such a position of the pores is evidently only accidental, depending upon the mode in which the quite young and still fan-shaped colony first became twisted; if towards the poriferous side, the pores remained on the inner side; if in the reverse direction the pores remained outside. It needs only to observe the irregular manner in which all these colonies bend in and out in every direction to become convinced that the same was the case also in the young stage, so that the position of the pores must be more or less accidental, and cannot be used for the distinction of genera.

The general geological distribution of this sub-family is similar to that of the preceding, but in the present one on the whole the several genera show a larger geological range.

In the Salt-range the present sub-family is more largely represented than the preceding one, three genera—*Polypora*, *Phyllopora*, and *Synocladia*—being each represented there by several species.

Sub-family: *GONIOCLADINÆ*.

The most striking character of this sub-family consists in the circumstance that the branches of the colonies are compressed, not from front to back as in the other sub-families, but laterally, so that on the obverse as well as on the reverse side of the branches a highly projecting keel is produced.

The colonies themselves are fan-shaped or arborescent, and are above all characteristically distinguished by the circumstance that the branches and interstices are not well distinguishable, the whole forming a rather irregular net-work.

The genera belonging to this sub-family are :—

1. Goniocladia, Etheridge, 1876: Geol. Mag., dec. II, vol. III, p. 522. (= *Carinella* Etheridge). The colony is fan-shaped and forms an irregular net-work of tortuous anastomosing branches, producing generally hexagonal fenestrules. Both the poriferous and the reverse sides of the branches are strongly keeled. There are several rows of pores on both sides of the keel. Carboniferous to permian.
2. Ramipora, Toula, 1875: Neu. Jahrb. für Min. u. Geol., p. 230, pl. X, fig. 1. Colony arborescent, with a median axis bearing opposite branches, which again are provided with opposite branchlets; these latter anastomose and thus form an irregular net-work. Both faces of all these parts bear a strong keel, and on the poriferous side there are several rows of pores on each side of the keel. The genus occurs in the permo-carboniferous beds of Spitzbergen.

Of these two genera only the first occurs in the Salt-range, and has furnished there one species.

Sub-family : *FENESTELLINÆ.*

Genus : FENESTELLA, Lonsdale.

The colony, if perfectly preserved, is infundibuliform or fan-shaped, often of a very considerable size. It is composed of numerous thin dichotomous branches which originate at the root-like base and extend in a somewhat radial direction towards the periphery ; they are connected together by thin straight dissepiments, giving a finely reticulated appearance to the whole colony. The round entrances to the cells or pores are distributed in two rows on the obverse side of the branches. Between these two rows of pores a high keel runs along, on the top of which smaller accessory pores are sometimes situated. These need not always be open ; sometimes they are shut and replaced by little nodules, sometimes the openings are only slit-like. The dissepiments are devoid of pores, and form together with the intertices of the branches adjoining them more or less regular quadrangular or somewhat roundish fenestrules.

The basal-plate, which covers the non-poriferous side, is longitudinally striated.

The genus is well distinguishable from all the others of the family by the absence of any axis ; by the two rows of cells on the branches separated from each other by a high keel ; and by the dissepiments being devoid of pores.

The distinction of species within this genus is beset with great difficulties. It needs only a glance into Shrubsole's review of the British carboniferous *Fenestellidæ* to become convinced of this. Though we agree perfectly with that author as to the effects of age and preservation on colonies of this genus, yet we cannot detect in the Indian specimens differences due to those influences comparable in extent to those stated by him to occur in English species.

With progressing age the basal-plate especially increases considerably in thickness, and on the obverse side the pores seem sometimes to be closed, but the arrangement of the pores is never altered. In the peripheral parts of the colonies, differences due to preservation are caused to the extent that the accessory pores on the median keel are sometimes closed, sometimes open, and thus produce a rather different appearance of the branches, the arrangement of the primary pores or cell-openings is however invariable. Thus it appears to us that the chief characters for the distinction of species within this genus must be taken from the size of the branches and of the fenestrules, and from the arrangement of the cell-openings.

According to these views we can distinguish two species of Fenestella among the Indian materials. One of these is identical with an American species and will thus bear the name of *Fen. perelegans*, Meek ; the other cannot well be identified with any species already described, and we therefore are obliged to introduce a new name for it : *Fen. jabiensis*, W. and P. The first of these occurs in the middle Productus-limestone, while the second is geologically somewhat younger, and extends from the top beds of the middle into the upper division of the Productus-

limestone. A third species seems to occur in the Salt-range, but it has been found only in such an incomplete state of preservation that it is impossible to say anything positive of it. This form occurs in the *Neobolus*-beds and will be quoted as *Fenestella* (?) *sp. indet.*

1. Fenestella perelegans, Meek, Pl. LXXXVII. fig. 1-3.

1871. *Fenestella shumardi*, Prout ?: Meek: in Hayden's final report on Nebraska, p. 153, pl. VII, fig. 3.
„ *Fenestella perelegans*, Meek: *ibid*, p. 153, line 4 from below.

The colony is fan- or funnel-shaped, forming on the whole an exceedingly fine net-work.

The branches are straight, of equal thickness for their whole extent, and rather coarsely striated longitudinally on the non-poriferous side. They divide frequently and at rather regular distances into two, and are a little swollen at the point of division. Otherwise they extend tolerably parallel to each other.

The dissepiments bear a fine striation parallel with their longer extension. They are always thinner than the branches, and somewhat thickened at each end where united with the branches.

The fenestrules are oval or rectangular with rounded corners. They are always longer than broad, the length being about once and a half the breadth. The breadth of the fenestrules on the contrary is again only about one half the breadth of the branches. There are about 10 fenestrules within the space of 5mm. in the direction of the extension of the branches as well as in the transverse direction.

The comparatively large round cell-openings are in the specimens at our disposal on the inner side of the funnel formed by the whole colony. They form on each branch two alternating rows between which a very distinct keel extends. Their arrangement is with very remarkable constancy such that a pore is always situated at each end of the dissepiments and one on the interstices between, that is on the longer sides of each fenestrule. This is all that can be seen with an ordinary pocket lens. With a lens of stronger magnifying power one can however observe that the keel bears small accessory pores, which are sometimes closed, sometimes open; when they are closed, the keel forms a distinctly waved line, on which from distance to distance little swellings are observable; when the pores are open the waved line is resolved into a number of these very fine pores placed alternately along the top of the median keel.

The non-poriferous side of the branches is evenly vaulted and occupied by the so-called basal-plate. This bears generally a rather coarse longitudinal striation, and is often so thin that the cells can be seen through it. Towards the root of the colony the basal-plate becomes generally considerably thicker.

From this description it will already appear that all the parts of this species are of exceeding smallness. The whole colony however can attain the height of 50 to 60mm. and even more.

In one of the specimens (from Gulámi) the natural colouring of the species, a dark coral-red, seems to have been preserved.

Locality and geological position.—This is a rather rare species; there are only three specimens of it in the Salt-range collection. All three were collected in the middle Productus-limestone. One of them was found at Khura in the upper region of the middle division, another at Musakheyl, and the third at Gulámi, both the latter in the middle region of the same division.

Remarks.—There cannot, it seems, be much doubt that the Indian fossils are identical with the American species, to which they have been assigned by us, all the chief characters agreeing exactly in both forms. It must however be remarked, that it is only the name of *Fen. perelegans* that can be applied and not that of *Fen. shumardi*, Prout, which has been also adduced by Meek. The true *Fen. shumardi* though it has never been figured, can even from the description be stated to be altogether different from the form here under consideration. The number, as well as the arrangement of the cells adjoining each of the fenestrules, is quite peculiar in the Indian specimens, and Mr. Meek was thus very right in introducing a new name for the present form.

The species was originally described by Meek from division C of the Nebrasca section.

Of European species *Fen. nodulosa*, Phill., with which a number of other forms have been united by Shrubsole, can be compared. It is distinct from the Indian and American form by the less regular arrangement of the cells, two of which often occur along the margin of one fenestrule, a case which has never been observed in *Fen. perelegans*. Also the fenestrules themselves are of different dimensions.

Whether the specimens that have been described by Toula from Barentz Land near Novaia Zemlia, under the name of *Fen. cf. shumardi*, belong really to Prout's species, or should be united with the present one cannot be decided, because only the non-poriferous side is known, and even of this the indications are rather incomplete.

2. Fenestella jabiensis, Waagen & Pichl, n. sp., Pl. LXXXVII, fig. 4, Pl. LXXXVIII, fig. 1-2.

The colony very probably was infundibuliform, and increased very rapidly in size by the progressive augmentation of the branches.

The comparatively thick branches bifurcate frequently and within short distances. On the non-poriferous side they appear somewhat crooked. The dissepiments are on the same level as the branches, and form together with the interstices fenestrules of a roundish or oval shape. On the poriferous side, on the contrary, the branches appear almost quite straight and the dissepiments are deeply sunk between them, the fenestrules becoming more rectangular, with rounded corners. The dissepiments are generally but little narrower than the branches, and are somewhat

broader at the place where they unite with the branches than in the middle. The fenestrules are narrower than the branches, and generally about twice as long as they are broad. Within the distance of 5mm. there can generally be counted 4 to 5 fenestrules in the direction of the extension of the branches and 6 in the transverse direction.

The small round cell-openings are equidistant from each other on the poriferous side, and are placed in two alternating rows on each side of the high median roof-shaped keel, and very near the margins of the fenestrules, whereby the latter often have an indented appearance. There are generally three to four pores within the space of one fenestrule, and so arranged that the first and the last occur just in the lower and upper corners of the fenestrule, or stand opposite the broadened termination of the dissepiment.

Along the top of the median keel a great number of very small accessory pores are somewhat alternately placed, but they can only be observed with a very strongly magnifying lens.

On the non-poriferous side the branches are flatly vaulted and indistinctly striated longitudinally. When the very thin basal-plate is removed by weathering or detrition, the cells can be seen as little tubes directed obliquely upward and outward.

There were three specimens of this species in the Salt-range collection, but only exposed to view on the non-poriferous side. In one of the specimens it was found possible to clear the opposite side from the adhering rock; but though this preparation answered all purposes of description, its characters could only be seen with difficulty and under favourable circumstances. Thus it has happened that the artist has not quite correctly represented the species in the drawings on Pl. LXXXVIII; it may then be pointed out that the pores adjoining the dissepiments are not in reality more distant from each other than the others along the margins of the fenestrules, the distribution being much more regular than is represented in the drawing. In the outermost branches on the right and on the left of the figure the drawing most nearly approaches the reality.

As to the size of this species, nothing can be indicated from the few fragments that have been found in the Salt-range.

Locality and geological position.—The species is represented in the Salt-range collection by three fragments. Two of these were found at Jabi in the Cephalopoda-bed of the upper division, and the third at Khura in the upper beds of the middle division of the Productus-limestone.

Remarks.—The present species belongs to a very remarkable group of forms within the genus *Fenestella;* it is distinct from all the rest of the same genus by the circumstance that the two faces of the colony have very different aspects, on the poriferous side the fenestrules appearing more or less rectangular, while on the other side they appear oval or nearly circular. This peculiarity is caused by the position of the comparatively very broad dissepiments in the plane of the non-poriferous side.

This group of forms is composed, as far as we are aware, of *Fen. veneris*, Fischer v. Waldheim, *Fen. fossula*, Lonsd., and the Indian species here under description. Of these three the *Fen. veneris*, Fisch., is geologically the oldest, having been described originally from the upper-carboniferous-limestone of Moscow. The Australian *Fen. fossula* may be about of the age of the coal-measures, and our Indian *Fen. jabiensis* belongs probably to the permian formation.

In the mountain-limestone proper this group of forms seems to be entirely absent.

As regards the specific distinction of the Indian form from other allied species, we must confess that it is very nearly related to the other species of the same group; nevertheless there are some differences which forbid a specific identification. The most nearly allied form is *Fen. veneris*, Fisch. As far as this species has been made known by Trautschold's description, which is however, we are sorry to say, rather defective, it seems that it is chiefly distinct from the Indian form by its smaller size. Trautschold counts 16 fenestrules in the longitudinal and 20 in the transverse direction within the space of 10mm. which indicates considerably smaller dimensions than in *Fen. jabiensis*. *Fen. fossula*, Lonsd. seems to agree nearly in size with our Indian form, but the indications given in the description are still more rudimentary than in the preceding case. Nevertheless according to the drawings given by Lonsdale, this Australian form also seems to be different from the Indian one, the difference being chiefly apparent in the condition of the keel on the poriferous side. In the Indian form the keel is furnished with a great number of very small accessory pores, which alternate and thus form a waving line; in the Australian form, on the contrary, there are few accessory pores of comparatively large size and so placed on the top of the keel that one accessory pore is always situated between two of the large cell openings. This difference seems sufficient to distinguish specifically between the Indian and the Australian forms.

Of other species *Fen. Popeana*, Prout, might perhaps be compared; but there is no drawing of this American form, and thus a comparison becomes very difficult. But from the description it seems that the American species can well be distinguished from the Indian one by the insignificant development of the keel on the poriferous side of the former.

Among the mountain-limestone species of Europe, *Fen. tenuifila*, Phill. resembles *Fen. jabiensis* by the similar distribution of the cell-openings. It belongs however to a quite different division of the genus, as it exhibits very thin dissepiments and rectangular fenestrules on both faces of the colony.

3. (?) Fenestella sp. indet., Pl. XCI. fig. 6.

In the grey slaty micaceous shales which form the *Neobolus*-beds in the gorge above the salt-mines of Khewra an impression which resembles a *Fenestella* has

been found. So much can be stated that the branches are of a calcareous substance, but beyond this it was found impossible to make out anything.

Bad as this specimen is we thought it worth a short notice, as the bed in which it occurred has furnished up to the present only those remarkable Brachiopods of the order *Lyopomata* that have been described above. The occurrence of something like a *Fenestella* in these beds gives at least some hope that other fossils may yet be found in time.[1]

Sub-family: *POLYPORINÆ.*

Genus: POLYPORA, M'Coy.

The colonies of this genus are fan-, funnel-, or cup-shaped. They are composed of dichotomous branches rising from a common root. They are comparatively very thick, and already this gives to this genus a very characteristic appearance,

[1] In the course of preparing the *Brachiopoda* I have detected another fossil. It was contained in a specimen labelled "Chel-hill" by Mr. Wynne, without indication of any horizon. The rock is exactly similar to the *Neobolus*-beds of other localities, but *Neobolus* itself and the other *Lyopomata* that generally are found with it are altogether wanting. The fossils in this rock-specimen are small *Hyolithes*, of which several specimens could be extracted. Mr. Wynne mentions in his report several bands of rocks at Chel-hill very similar in appearance to the *Neobolus*-beds, but far above these, in the Magnesian-sandstone, and the rock-specimen may have come from one of these bands. The species may best bear the name of—

HYOLITHES WYNNEI, Waagen, n. sp.

The subjoined woodcut represents the species in natural size and enlarged:—

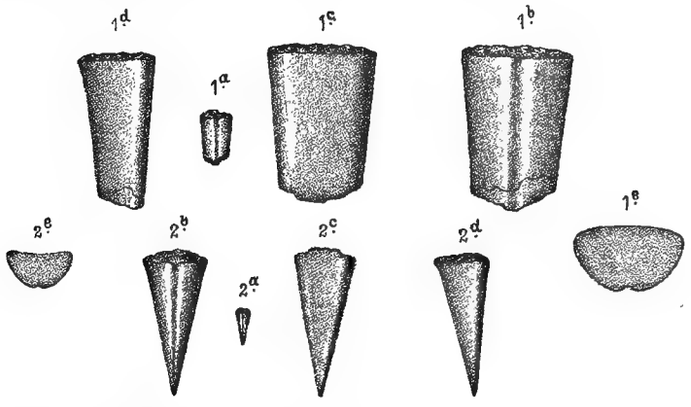


Fig. 25.—HYOLITHES WYNNEI, Waagen, n. sp. 1, fragmentary specimen with upper end partly preserved; 1 *a*, natural size; 1 *b*, view from the front; 1 *c*, view from the back; 1 *d*, lateral view; 1 *e*, section, the latter four figures enlarged; 2, small specimen with the apex preserved; 2 *a*, natural size; 2 *b*, *c*, *d*, *e*, different views enlarged (legend as in 1).

The whole fossil forms a small obtusely triangular pyramid, of which the larger face is concave near the apex and flatly vaulted near the aperture. The smaller faces are transversely vaulted for their whole extent, and are separated in the middle by a shallow longitudinal furrow. There are only internal casts known to me.

It seems that these little things do not agree with any species hitherto described. They seem to be most nearly related to *Hyolithes lanceolata*, Moris, from Australia, but deviate also from this form by the longitudinal furrow on the cast.

From *Hyolithes orientalis* W., described above, page 177, they are distinct by their larger size and quite smooth surface.

altogether deviating from *Fenestella*. The branches are connected together by numerous dissepiments, forming a net-work, showing either quadrangular or polygonal, or round fenestrules arranged radially in regular rows, which can be distinctly discerned extending from the root to the margin of the colony.

The branches are provided on one side (mostly the inner one) with numerous, 3 to 6 or 10, alternating longitudinal rows of pores. These latter are generally arranged distinctly in quincunx; they are round and their margin is often somewhat projecting from the surface of the branches. The cells in which the animals lived take their origin at the axis of the branches and rise from there in an oblique direction upward and outward. The dissepiments are without cells, though sometimes the cells extend on to them laterally from the branches so far that the space devoid of cells becomes very narrow. There is no keel on either side of the branches.

The non-poriferous side is occupied by the basal-plate, composed of one or more layers of capillary fibres, and is thus for the most part distinctly striated longitudinally. This basal-plate is usually of considerable thickness.

The specific distinctions within this genus are again very difficult, as there are no striking characters upon which they could be founded. All the species belonging to the genus seem at a first glance very much alike, and only after a more careful comparison are differences observed in the number of rows of pores on the poriferous side, in the size and arrangement of the fenestrules, and so on; but the entire absence of striking characters makes a grouping of the species extremely difficult. There might perhaps, as in *Fenestella*, be distinguished two groups, one which has still somewhat of a *Fenestella* in its habitus, and in which the poriferous and the non-poriferous sides are nearly identical in general appearance, and another group in which the poriferous side seems to bear much smaller fenestrules than the non-poriferous one. These two groups are however not very strictly distinct from each other, and it seems of not much practical value to make such a distinction.

The genus *Polypora* is extremely rich in species, but a great many of them have been described only from the non-poriferous side. Species begin to appear already in silurian strata, but the chief development of the genus seems to be attained in carboniferous times. In the permian formation it is still represented.

In the Salt-range we count eight species of *Polypora* which range through the whole extent of the Productus-limestone. In the lower division only a single species, *Polyp. vermicularis*, W. and P., has been found up to the present; it is restricted to that division. In the middle division the following six species occur, of which four are restricted to that division and two extend also into the upper division:—

Polypora koninckiana, W. and P.—middle and upper.
„ *megastoma*, Kon.—middle.
„ *gigantea*, W. and P.—middle.
„ *ornata*, W. and P.—middle and upper.
„ *sykesi*, Kon.—middle.
„ *transiens*, W. and P—middle.

In the upper division there is only a single species, which is restricted to that division: *Polyp. biarmica*, Keys.

It thus appears that in the Salt-range the genus has its chief development in the middle division of the Productus-limestone. This may however be partly due to the local facies of these beds, as coral limestones.

1. Polypora koninckiana, Waagen and Pichl, n. sp., Pl. LXXXVII, fig. 5, Pl. LXXXVIII, fig. 4, Pl. XC, fig. 1.

1863. *Polypora fastuosa*, Koninck: Quart. Journ. Geol. Soc. Lond., vol. XIX, p. 5, pl. X, fig. 4, (non *Gorgonia fastuosa*, Kon., 1844, *Polypora fastuosa*, Orb. 1847.)
1863. *Polypora fastuosa*, Koninck: Foss. Paléoz. de l'Inde, p. 20, pl. I, fig. 4.

This is one of the commonest species of *Bryozoa* in the Salt-range. There are numerous good-sized fragments in the Salt-range collection which all are flabelliform; it seems however that when complete the colony had an infundibuliform shape of considerable size. The branches composing the colony very often bifurcate at distances of from 6 to 12mm., whereby the whole net-work rapidly augments in lateral extension. The breadth of the branches is generally 2mm.; it must however be remarked that this breadth is not uniform; it is a little larger just before the branches divide into two, and a little smaller immediately after this division has taken place. On the non-poriferous side the branches appear much narrower, whereby a very different appearance of the two faces is produced.

On the poriferous side the surface of the branches is well rounded transversely. The dissepiments appear about one-half as broad as the branches, very short, and a little broadened at both ends. They bear a distinct striation parallel to their length. Owing to their small diameter they are sunk in between the branches, which project considerably above them chiefly on the poriferous side, so that on this side they nearly disappear between the branches and are situated in deep furrows.

The fenestrules, which are hemmed in by the branches and dissepiments, are of an elongately oval shape, about twice as long as they are broad. Their lateral margins sometimes appear indented, when the fenestrules are filled with stony matter in such a manner as to reach the first lateral row of cell-openings. There are about 4 fenestrules in a longitudinal, and 5 to 6 in a transverse, direction within the space of 10mm.

The large round cell-apertures have raised margins when the surface of the branches is quite well preserved; when this is not the case, these margins first disappear; and if the deterioration progresses further the cell-openings assume a rhombic aspect. These pores are regularly arranged in 5 to 7 alternating longitudinal rows, so that on the whole they are placed very regularly in quincunx. According to this arrangement, obliquely ascending rows of pores can be distinguished, each of which is generally composed of 5 to 7 pores, only just before the bifurcation of the branches 8 pores can sometimes be counted in the oblique row. Six of these rows terminate along the side of a fenestrule.

If the surface of the branches is perfectly preserved between the cell-openings fine longitudinal waving lines can be observed, by which these pores are partly surrounded.

The non-poriferous side of the colony is provided in the vicinity of the base with long root-like processes, devoïd of cells and longitudinally striated. It is probable that these organs served as supports for the increasing colony. Also in other respects this side presents an aspect differing much from that of the poriferous side. The branches appear much narrowed, about of an equal breadth with the dissepiments and sometimes angularly bent. They cannot always be easily followed, on account of the small difference between them and the dissepiments. The fenestrules appear on this side much larger, somewhat rectangular, not much longer than broad, or even roundish.

The colony does not seem to have attained very large dimensions; the utmost size it ever reached may have been 50 to 80mm.

Locality and geological distribution.—The species seems to occur most numerously in the middle division of the Productus-limestone. It has been found in these beds in the middle zone (Virgal, 1 sp. and Vurcha, 1 sp.), and in the uppermost strata (Musakheyl, 2 sp.). The species extends however also into the upper division of the Productus-limestone, where it has been found in the *Cephalopoda*-bed at Jabi and at Chidru.

Remarks.—This species was originally identified by Mons. de Koninck with his *Gorgonia fastuosa* from the mountain-limestone of Belgium. It would therefore have been of much interest to compare original specimens of the two species, but this has, we regret to say, been impossible; Mons. de Koninck himself, in his great kindness, took much trouble to procure us a specimen of *Pol. fastuosa* from Belgium for comparison, but he did not succeed, as the species is so very rare. But in a letter addressed to one of us, he stated that he now thought his species was very materially different from the Indian fossil which he had formerly united with it, and that we ought to give a new name to the Indian form. We thus have decided to give the name of *Pol. koninckiana* to this fossil in order to express our gratitude to Mons. de Koninck for his kind and liberal endeavour to help us in our studies.

Mons. de Koninck expressed the opinion that the Indian form was distinct from the original *Pol. fastuosa* by broader branches and more numerous pores, an opinion that is perfectly borne out by the drawings in his "Déscription des Animaux Fossiles" Pl. A, fig. 5. From these drawings it appears that *Pol. fastuosa* has larger and more rectangular fenestrules, narrower branches and generally only five alternating rows of pores. Nevertheless *Pol. fastuosa* seems to be a very near relation of our *Pol. koninckiana*, and it is not improbable that the two stand in a developmental connection.

Other forms that have been described under the name of *Polypora fastuosa*, Kon., such as those mentioned by Toula from Barentz Land and Spitzbergen, are perhaps identical with the true *Pol. fastuosa*, but from *Pol. koninckiana*, here described, they deviate by different dimensions and a different number of pores.

Most nearly allied to the species here under description seems to be *Polypora marginata*, M'Coy, on account of its large cell-apertures and the presence of waving lines between them. The singular configuration of the branches, which is considered by M'Coy as the chief character of the species is probably only caused by a peculiar condition of preservation. From *Pol. konînckiana* it can be distinguished by its less numerous longitudinal rows of pores.

Polypora ampla, Lonsdale, might also be compared, but its preservation is generally so unsatisfactory that nothing definite can be made out. De Koninck, who makes it a distinct genus, *Protoretepora*, mentions only three rows of pores. This would remove it far from our *Pol. koninckiana*, though the dimensions and the shape of the fenestrules are similar. That it is very doubtful whether the genus *Protoretepora* should be retained has been mentioned already in the introduction to the genus *Polypora*.

2. Polypora megastoma, Koninck, sp.; Pl. LXXXVIII, figs. 3, 5, 6, 7; Pl. LXXXIX, fig. 3.

1863. *Fenestella megastoma*, Koninck: Quart. Journ. Geol. Soc. Lond., Vol. XIX, p. 5, pl. II, fig. 3.
1863. *Fenestella megastoma*, Koninck: Foss. paléozoiques de l'Inde.
1878? *Polypora megastoma* (Kon.) Etheridge: Quart. Journ. Geol. Soc. Lond., vol. XXXIV, p. 621.

The colonies of this species are on the whole fan-shaped, with a certain propensity towards the formation of irregular net-work of various shapes. In the parts of the colony adjacent to the root, the branches forming the net-work bifurcate much more frequently than further on.

The branches are on the poriferous side about 2mm. broad, and bifurcate generally within distances of from 5 to 15 or 20mm. Before the bifurcation takes place they are very little thickened, and the angle of bifurcation is flatly rounded off. In the peripheral parts of the colony the branches appear more or less parallel to each other, while in old specimens and in the parts neighbouring the root, the bifurcation occurs so often that no parallelism can be observed.

The short horizontal dissepiments are either alternating or nearly opposite to each other. Their breadth is about half that of the branches, but they are somewhat broadened at both ends. They are distinctly striated longitudinally, and their surface is on the whole on a much lower level than that of the branches.

The fenestrules are more or less rectangular, with rounded corners. They are always longer than broad (about $2\frac{1}{2}$ to 3mm. long and $1\frac{1}{2}$mm. broad), and three of them measured in the longitudinal direction occupy the space of about 12mm. Within the same space there can be counted 4 to 5 rows in the transverse direction.

The round cell-openings, which however appear in weathered surfaces more or less rhombic, are very numerous, arranged very regularly in quincunx, forming 7 to 10 alternating longitudinal rows. In this arrangement also oblique rows can be distinguished, ascending from both sides and intersecting. The number of pores

in these rows is seven to ten. Of these obliquely ascending rows there can be counted about eight along the lateral margins of one fenestrule. Sometimes the pores extend rather far on to the dissepiments, so that the poreless space on these latter becomes very narrow.

On the non-poriferous side the branches appear much thinner and angularly bent, following more or less a zig-zag line. Sometimes they bear root-like longitudinally striated prominences without pores. The dissepiments are on the same level as the branches, are nearly as broad as the latter, and somewhat broader at both ends. The whole surface of the non-poriferous side is covered with very dense, waving, fine longitudinal striations.

The present species can attain very considerable dimensions. There are badly preserved fan-shaped expansions in the Salt-range collection probably belonging to the present species, with a diameter of about 150mm., although the root and the margin have been broken off. Thus we may take the size of complete specimens to be at least 200mm.

Locality and geological position.—This is again a rather common species in the Salt-range, but seems to be restricted to the middle division of the Productus-limestone. There are seven specimens, of which three come from Morah, one from Ramkhund, and two from Káfirkót from the middle region of the division; while two others have been found at Khura in the uppermost beds of the same division.

Remarks.—This species is very well characterised by the large rectangular fenestrules, by the numerous rows of pores, and by the circumstance that the bifurcation of the branches is also easily discernable on the non-poriferous side. By all these characters it is also distinct from the preceding *Pol. koninckiana*, W. and P. It must however be noticed, that when the preservation is exceptionally good, similar waving lines extending between the pores can sometimes be distinguished in *Pol. megastoma* as well as in *Pol. koninckiana*.

Mons. de Koninck originally described this species under the name of *Fenestella megastoma*. Already the size of this form and the thickness of the branches suggested to us that it was a *Polypora*, and the preparations made quite confirmed this supposition. That the forms we comprise under the name are really identical with those so described by Mons. de Koninck, is clearly shown by the non-poriferous side of our specimens, which are absolutely identical with Koninck's drawing.

The species has been also quoted by Mr. Etheridge from Feilden Isthmus in the arctic regions. It is highly probable that Etheridge's determination is right, but the indication cannot be controlled, as no figure is given.

As far as we are aware of, there is no other species with which *Pol. megastoma* could be more particularly compared.

3. Polypora gigantea, Waagen and Pichl., n. sp., Pl. LXXXIX, figs. 1, 2.

The colony forms very large fan-shaped expansions, consisting of a net-work of very large meshes.

The branches are round, comparatively thin, not broader than 1·5mm. They divide frequently, not always only dichotomously, but sometimes three or even more branches originate at the same spot. The splitting of the branches generally takes place at distances of from 10 to 20mm., corresponding to a distance of from one to three fenestrules, whereby the colony very quickly attains considerable dimensions in breadth. Before the division of a branch takes place, it is a little swollen, and the new branches diverge in such a manner as to leave a fenestrule of normal size between them. Otherwise the branches extend tolerably parallel to each other keeping a distance of about two millimetres. In some silicified specimens the non-poriferous side of the branches is weathered in such a manner as to present the appearance of a median longitudinal keel with the cells arranged in oblique lines on each side of it. A superficial observer would easily take such specimens as belonging to the genus *Fenestella*.

The dissepiments are short and thin, barely showing more than one-third of the thickness of the branches. On the poriferous side their surface is on a lower level than the surface of the branches. They are finely striated longitudinally, and slightly thickened where they unite with the branches.

The fenestrules are somewhat unequal in size, very elongately rectangular, with rounded corners, varying from 5 to 9mm. in length and 2mm. in breadth. Two fenestrules occupy about the length of 13mm. At the points where the branches divide the fenestrules are sometimes much smaller and round.

The cell-openings are round and very numerous, and are arranged pretty regularly in quincunx. They form 7 to 9 alternating longitudinal rows, which extend on the lateral parts of the branches, rather low down towards the non-poriferous side, in such a manner that their full number can only be counted, when the branches have been cleared all round from the adhering rock. Between the pores extend waving longitudinal lines, which are bent in such a manner that the single pores appear as if situated in the middle of a hexagonal space.

The non-poriferous surface does not deviate in its general aspect from the poriferous one. It is covered all over with a fine longitudinal striation.

This species seems to have attained a very considerable size. Specimens of 150mm. in diameter are mere fragments without the upper or lower parts; it seems probable that the entire colony may have attained at least 500mm. in height. This seems to be the largest species existing within the genus.

Locality and geological position.—Specimens of this species are rather rare. They are restricted to the middle region of the middle division of the Productus-limestone and have been found up to the present at three localities: at Vurcha (1 sp.), at Mora (1 sp.) and Trans-Indus at Rámkhund (1 sp.).

Remarks.—This beautiful species is distinguished from all others known to us by its great size, by the extremely large elongately rectangular fenestrules, and by the great number of longitudinal rows of pores. *Pol. gracilis*, Prout, which may perhaps be more particularly compared, has thinner branches, less regular

fenestrules and only four to five rows of cells. By similar characters can be distinguished *Pol. laxa*, Phill., sp.; *Pol. macropora*, Eichw. or *Pol. concatenata*, Eichw.

4. Polypora ornata, Waagen and Pichl., n. sp.; Pl. LXXXIX, figs. 4, 5, 6; Pl. XC, figs. 2, 3, 4.

The colony is largely infundibuliform and irregularly folded.

The branches are about 1mm. broad. They are flatly vaulted on the poriferous, as well as on the other side, and bifurcate very frequently in the vicinity of the root of the colony, while such bifurcation more rarely takes place in the peripheral parts. Just before the bifurcation the branches are generally somewhat broadened, and after it somewhat thinner. They extend generally parallel to each other, only in the folded peripheral parts of the colony the bifurcation as well as the extension of the branches is more irregular. The branches are commonly much altered by weathering, and then occasionally exhibit a rather strange appearance, being either quite flattened or bearing a sharp edge in the middle.

The dissepiments are short, about one-half as broad as the branches, and their surface is on a level only very little lower than that of the branches. They are somewhat broadened at both ends, indistinctly striated longitudinally, and the space devoid of pores is very narrow.

The fenestrules are about 1mm. in diameter. On the poriferous side they are somewhat smaller, oval in shape and longer than wide. On the non-poriferous side on the contrary they appear larger, mostly circular or also sometimes a very little longitudinally oval, but rarely somewhat broader than long. In much weathered specimens they often form deep funnels of a somewhat hexagonal circumference, and are separated from each other by high sharp crests (Pl. XC, fig. 2). They are arranged in such a manner, that not only longitudinal rows, but also obliquely ascending transverse rows can be distinguished. Within a length of 10mm. five to six fenestrules can be counted in the longitudinal direction, while there are always six within the same length in the tranverse direction.

The cell-openings are round, numerous, and are situated on the internal side of the infundibuliform colony. The pores are generally arranged regularly in quincunx and forming six alternating longitudinal rows on each branch. Just before the branches bifurcate they become broader, and at the same time also the number of pores is augmented, so that in this position eight rows can often be distinguished, but then also the arrangement is irregular and not in quincunx. The oblique rows of pores, ascending from both sides and intersecting each other, comprise generally from six to eight pores. Three to four of such rows terminate generally along the lateral margins of each fenestrule. Between the pores there extend fine waving longitudinal lines, causing the whole surface of the branches to be covered by a somewhat rhombic sculpturing. About where the corners of four of these rhombs approach each other minute adventitious pores occur (Pl. LXXXIX, fig. 6*b*.).

The non-poriferous side has an aspect somewhat different from that of the other side on account of the circumstance that the branches appear narrower, the fenestrules large and more roundish, and very often assuming an infundibuliform shape. The surface of the non-poriferous side bears a coarse longitudinal striation, covered by a not very fine granulation.

This is again a form which grew to very large dimensions. In specimens attaining a diameter of 200mm. the infundibuliform shape of the colony is no longer well marked, because in large specimens the colony spreads out almost horizontally, and often stops growth at one side much earlier than on the other, so that rather fan-shaped specimens are then produced. In specimens of this description the substance is so much thickened and incrusted that one cannot be sure which of the two sides is the poriferous one.

Locality and geological position.—The present species is not a common one, though it extends through the middle and upper divisions of the Productus-limestone. In the middle division it has been chiefly met with in the hard limestones of the middle region, and has been collected in these beds at Morah (1 sp.) and at Omar-kheyl (1 sp.). In the upper division specimens have been collected in the lower and middle regions at Bilot (1 sp.) and at Khura (2 sp.).

Remarks.—In respect of the size and shape of the fenestrules, the present species shows a certain similarity to *Pol. orbicrebrata*, Kays., of the carboniferous limestone of Petschora Land. There exists however a striking difference between the two in the smaller number of longitudinal rows of pores in the Russian species. Another species that might be compared is *Pol. subquadrata*, Toula, from carboniferous beds of Barentz Land. In this, as in the preceding species, a small number of alternating longitudinal rows of pores can be distinguished, in this case only four rows.

Pol. cyclopora, Eichw., shows a similar number of rows of pores as our *Pol. ornata* (7—8 rows), but the bifurcation of the branches has a different character, and the fenestrules are more angular. As however there exists no figure of the poriferous side a more close comparison is difficult.

On the whole the present one seems to be a well characterised and easily distinguishable species, which can chiefly be recognised by a poriferous side showing broad branches and dissepiments and small round or oval fenestrules, while the latter appear larger and often infundibuliform on the non-poriferous side.

5. Polypora sykesi, Koninck, sp.; Pl. XCI, figs. 1, 2.

1863. *Fenestella sykesi*, Koninck: Quart. Journ. Geol. Soc. Lond., Vol. XIX, p. 5, Pl. I, fig. 1.
1863. *Fenestella sykesi*, Koninck: Fossiles paléoz. de l'Inde.

The colony was very probably infundibuliform, with irregular folds towards the periphery, some lobes of which were entirely rolled in.

According to different modes of growth and preservation the rather thin branches appear sometimes tolerably straight, sometimes angularly bent, following a zig-zag line, in which latter case their non-poriferous side is often weathered so as to appear carinated; they bifurcate frequently, within distances of from 8 to 16mm. and their breadth augments very considerably before the division takes place. In folded specimens the ramification is much more irregular, and on the enrolled peripheral lobes the branches appear thicker and the fenestrules larger on the convex than on the concave side.

The generally alternating dissepiments are short, but little narrower than the branches, and somewhat broadened at both ends.

The fenestrules are nearly circular on the non-poriferous side, and longitudinally oval on the poriferous one. They form generally very distinct longitudinal rows, which more or less alternate so that the fenestrules on the whole appear very regularly arranged in quincunx as in *Phyllopora*. There are generally 6 to 7 fenestrules within the distance of one centimetre in the longitudinal direction. Transversely it is very difficult to take measurements, on account of the alternating arrangement of the fenestrules.

It has been found impossible to clear the poriferous side of the present species from the adhering rock, as all the specimens in the collection were preserved in such a hard siliceous or sacharoid limestone that the substance of the specimens was found to be less hard than the matrix in which they were contained. Consequently nothing could be done, but to make the pores visible by grinding down the non-poriferous side to near the poriferous surface. By such means it was ascertained that there were five alternating longitudinal rows of pores, and that the pores were very regularly arranged in quincunx. By this arrangement oblique rows are produced ascending from both sides and intersecting each other. There are four to five pores contained in each oblique row, and about four of such rows terminate along the lateral margins of one fenestrule. On the dissepiments there is but a narrow space free of pores.

The surface of the non-poriferous side is finely striated longitudinally.

The present species seems to have attained no considerable dimensions, as all the specimens at our disposal are of a very moderate size; it is not probable that the species ever exceeded 100mm. in height.

Locality and geological position:—*Pol. sykesi* is a rather rare species. It is entirely restricted to the massive limestones in the middle region of the middle division of the Productus-limestone, and has been found at Katta (2 sp.), at Morah (1 sp.) and at Musakheyl (1 sp.).

Remarks:—There has been figured by Mons. de Koninck, in his description of the fossils collected by Dr. Fleming in the Salt-range, a *Fenesteila sykesi*, which is represented from the non-poriferous side; the original has been lost. Under such circumstances we could only select among our materials specimens in which the non-poriferous side most nearly agreed with that of *Fen. sykesi* as represented in the

drawing, and then attempt an identification. Of the original specimen of *Fenest. sykesi*, the poriferous side was not known at all, and thus that specimen may as well have been a *Polypora* as a true *Fenestella*, and the comparative thickness of the branches suggests its *Polypora* nature. In specimens which we thought proper after most careful comparison to unite with Koninck's species, we soon detected numerous rows of cells and thus had to place them in the genus *Polypora*.

The present species varies very much according to its different states of preservation. Specimens in which the non-poriferous side is well preserved have the aspect represented in Mons. de Koninck's figure, and which is also exhibited in our figure Pl. XCI, fig 1. If however the specimens are more strongly weather-worn, then the fenestrules appear funnel-shaped, the branches narrower, and crested. Such a specimen is represented in Pl. XCI, fig. 2.

To this latter form the European species, *Polypora papillata*, M'Coy, can be compared. It is however distinct from the Indian species by narrower branches and less numerous rows of pores.

6. Polypora biarmica, Keyserling, Pl. XC, figs. 5, 6, 7.

1846. *Polypora biarmica*, Keyserling: Reise in das Petschora-Land, p. 191, pl. III, fig. 10.
1859. *Polypora biarmica*, (Keys.) Prout: Transact. St. Louis Acad. of Sci., I, p. 450.
1861. *Polypora biarmica*, (Keys.) Geinitz: Dyas, II, p. 117.
1866. *Polypora biarmica*, (Keys.) Geinitz: Carbon & Dyas in Nebrasca, p. 68, pl. V, fig. 13.
1872. *Polypora sp. indet.* Meek and Hayden: Final Rep. Geol. Surv. Nebrasca, p. 155, pl. VII, fig. 6.
1877. *Polypora biarmica*, (Keys.) Miller: Amer. Palæoz. Foss., p. 99.

The colony is apparently spread out in a flat funnel, the margins of which are sometimes irregularly folded.

The branches are straight, always broader than the fenestrules, and their appearance is rather different, according to the different sides of the colony. On the poriferous side they appear rather stout, frequently and regularly bifurcated, and considerably broadened just before the bifurcation takes place. Their surface is flatly vaulted. On the non-poriferous side, on the contrary, they appear thinner and not quite so straight. In specimens in which the curvature is stronger, the bifurcation of the branches becomes more irregular, and these are themselves very closely approximated to each other.

The dissepiments are very short on the poriferous side, or even barely distinguishable, in cases when the branches are very closely approximated. They are about half as broad as the branches, and situated at a somewhat lower level than the surface of the latter. On the non-poriferous side they appear somewhat longer and are situated about in the same level as the surface of the branches.

The fenestrules again appear very different according to the different sides of the colony. On the poriferous side they are very small, elongately oval, generally about $\frac{2}{3}$ as broad as they are long, sometimes however much narrower and slit-like. They are often arranged in quincunx and seem to form obliquely ascending rows.

The sides of them appear sometimes indented by the somewhat projecting cell-openings. On the non-poriferous side the fenestrules appear nearly circular, only rarely oval.

There are four to five fenestrules within a length of 5mm. in the longitudinal direction, and in the transverse direction there are generally five to six within the same distance.

The large round cell-apertures have slightly projecting margins. They generally are arranged in three to four alternating longitudinal rows. Mostly one finds only three rows immediately after a bifurcation has taken place, higher up four rows may be distinguished, while on the broadened part of the branch just below the bifurcation up to six rows may be distinguished. In the obliquely ascending rows, formed by the alternating position of the pores, generally three pores can be counted composing one row, while more rarely four such pores occur. Along the lateral margins of one fenestrule generally two such oblique rows terminate, more rarely one or three. The pores often extend laterally so far on to the dissepiments that only a very narrow space remains free of pores, which is sometimes barely recognisable. In the only specimen at our disposal showing the non-poriferous side, this surface is not longitudinally striated, but covered with comparatively large round pores or holes, which are quite irregularly distributed, and might be mistaken for real cell-openings.

The size of this species seems to have been very moderate, but there is no entire specimen known to us, and thus we cannot give any positive indications.

Locality and geological position.—There are only two specimens of this species in the Salt-range collection, so it would appear that the form was very rare. It is moreover entirely restricted to the upper division of the Productus-limestone, in which it has been found up to the present only in the Cephalopoda-bed at Jabi (1 sp.) and at Chidru (1 sp.).

Remarks.—It is of much geological interest to find this permian species represented in the Salt-range, and on this account the identification calls for some further remarks. It would have been very desirable to compare the Indian specimens with authentic specimens of *Pol. biarmica*, but it seems that Count Keyserling's species is also a very rare one, as in none of the large museums which I had occasion to study more in detail, were specimens of the species to be found, and all endeavours to procure specimens for comparison failed. We thus were compelled to content ourselves with the comparison of our Indian materials with Keyserling's drawings, and this comparison was entirely in favour of an identification, as the Indian specimens seemed to be in every respect identical with Keyserling's description and figures, with the sole exception that the net-work of the Indian forms is perhaps a very little finer than in the Russian specimen from which the species was originally described. The difference is however a very small one, such as can be often observed in fragments from different parts of one and the same colony, and cannot prevent our placing the Indian specimens in Keyserling's species.

The specimen from division C of the Nebrasca city section, and identified by Geinitz with *Pol. biarmica*, seems to us quite correctly identified, though Meek, in his endeavour to dispute the permian age of these beds, has doubted that determination.

The species is however of a type which is not exclusively permian, but commences already in the upper carboniferous-limestone of Russia, where *Polypora martis*, Fisch, is a very characteristic representative of it. It is very much to be regretted that Trautschold's enlarged figure of this species is so very defective, and that no representation of the species in natural size was given. As far as can be made out from Trautschold's description and figure, this species of Fischer's can at all events be distinguished from our Indian specimens of *Pol. biarmica*, as these have a finer net-work. Whether such is the case with European specimens of *Pol. biarmica*, I cannot positively assert, but it is highly probable. If it be so, the *Pol. martis* must be considered beyond doubt as the ancestor of *Pol. biarmica*, and thus the two must be brought into developmental connection.

The existence of this very nearly allied form in geologically older beds makes other quotations of *Pol. biarmica* appear a little doubtful. Thus the form that has been described by Toula from Barentz Land may well belong to *Pol. martis*. The same is the case with the *Pol. biarmica* quoted by Etheridge from Fielden Isthmus.

In the older beds of the carboniferous formation, in the mountain-limestone, so far as we are aware of, there is no species closely related to *Polyp. biarmica*. The only form which might be compared is *Pol. papillata*, M'Coy, which is very similar to the species here under consideration in the size of the fenestrules and in the number and general arrangement of the pores. It can however be well distinguished from *Pol. biarmica* by the more zig-zag bending of the branches, the longer and thinner dissepiments, which are entirely free of pores, and by the position of the pores regularly in quincunx. The American species *Polypora varsoviensis*, Prout, is very similar to *Pol. biarmica;* it may even be the same as Keyserling's species, or perhaps it should be identified with *Pol. martis*, Fisch.

7. Polypora vermicularis, Waagen and Pichl., n. sp., Pl. XCIV, fig. 7.

The colony is irregularly infundibuliform, with thick worm-like branches extending from the root upward between the more regular net-work.

The two sides of the colony are very different in aspect. The poriferous side shows the thick branches much less prominent, the fenestrules appear much narrower, and the branches of the net-work in consequence much broader than on the non-poriferous side, whereby a very different aspect is produced. The poriferous side is however known to us only from a comparatively small preparation; so we shall first describe the non-poriferous side.

The branches appear on this side of very unequal thickness and very different in aspect. The greater part of the colony is composed of comparatively thin

branches having a very uniform breadth of about 1 to 1½mm. They are angularly bent, following a more or less irregular zig-zag line, producing a tolerably regular net-work with the fenestrules sometimes approximately rectangular, sometimes polygonal.

Among these there extend thick round branches, which attain in the vicinity of the root a thickness of 3mm. decreasing and increasing again in thickness at irregular intervals. They bend deviously in all directions, sometimes bifurcating, sometimes remaining undivided for long distances. Their highly vaulted surface projects far above the level of the surrounding net-work.

The ramification of all the branches is extremely irregular and can be followed only with difficulty.

The dissepiments are very short, and either alternate or occur opposite each other along the branches. They are of about the same thickness as the branches, and lie on the same level with them on the non-poriferous side which is that immediately under description.

The fenestrules are of rather unequal size, and very variable in shape. Where the net-work is a little more regular and where the thicker sporadic branches do not interfere, the fenestrules are generally about twice as long as they are broad, that is to say, 2 to 2½mm. long and 1mm. broad. There are about three fenestrules within a length of 10mm. in the longitudinal direction, while in the transverse direction five longitudinal rows of fenestrules can be counted within the same distance.

The surface of the non-poriferous side is occupied in this case by an enormously thick basal-plate, which is composed of extremely numerous thin capillary tubes, producing a very fine longitudinal striation of the whole surface between which numerous small pores are visible.

The poriferous side, as far as it is known to us, is different from non-poriferous side chiefly by the greater breadth the branches seem to possess and the longer and narrower fenestrules. The pores with which the branches are covered, are very numerous, closely packed together and very regulary arranged in quincunx. There can be distinguished seven to nine alternating longitudinal rows of pores, and also, from the arrangement in quincunx, obliquely ascending rows, intersecting each other from both sides, each consisting of eight to ten pores. Along the lateral margins of each fenestrule seven to eight such oblique rows terminate. Between the pores fine waving longitudinal lines are distinguishable. On this side of the colony the fenestrules appear long and very narrow, generally three times as long as they are broad.

The dissepiments are placed at a much lower level than the surface of the branches.

As to the size the colony may have attained we are unable to decide as only a single specimen is at our disposal. It is however probable that it formed part of a rather large infundibuliform net-work.

A point yet to be noticed with regard to this fossil is its dark coral-red colour,

in striking contrast with the black rock in which it is contained; it may perhaps be the original colouring.

Locality and geological position.—The only specimen of this species in the Salt-range collection was found by Mr. Wynne in the Bukh Ravine, preserved in a black sandy limestone which there forms part of the lower division of the Productus-limestone.

Remarks.—The present species is very characteristically distinguished from all other species of the genus by the very irregular construction of the net-work, the very numerous and closely arranged cell-openings and the size and shape of the fenestrules. There is no described species known to us with which it could be more closely compared.

8. Polipora transiens, Waagen and Pichl., n. sp., Pl. XCI, figs. 3, 4, 5.

The colony was probably largely infundibuliform, in its outward appearance much resembling *Phyllopora*.

The branches are about 1mm. thick, angularly bent, following very distinctly a zig-zag line. In the lower regions of the colony they bifurcate rather frequently and regularly; in the upper parts on the contrary such a bifurcation takes place only very rarely, and the branches extend tolerably parallel to each other.

The dissepiments are short and on the non-poriferous side are of the same breadth as the branches. On this side they are also not depressed, but on the same level as the surface of the branches. On the poriferous side on the contrary they are depressed below the level of the surface of the branches, are narrower, and broadened at both ends.

The fenestrules are mostly arranged in alternating rows, so that distinct oblique intersecting rows can also be made out. In well preserved specimens they appear on the non-poriferous side hexagonal with rounded corners. Those however which do not alternate have a more rectangular shape. In specimens which are much worn by weathering, the fenestrules appear regularly oval. They are generally 2mm. long and $1\frac{1}{2}$mm. broad. Within a length of 10mm. there are generally three fenestrules in one longitudinal row. Measured along one of the oblique rows there are about four within the same distance.

On the poriferous side the fenestrules appear considerably smaller and regularly oval.

The cell-openings are regularly arranged in quincunx and form six to eight alternating longitudinal rows. They extend very far on to the dissepiments, so that generally only a very small space remains free of pores, in some cases this space becomes even so small that it appears quite obliterated. Along the lateral margins of each fenestrule there terminate about six oblique rows of pores.

The surface of the non-poriferous side is very finely striated longitudinally, often so finely that the striation even with a lens can barely be distinguished. From

distance to distance little calcareous protuberances, which probably served for the partial support of the colony and must be considered as root-like organs, are observable. They are probably identical with similar organs which have been described by us in *Polypora koninckiana*.

The species has apparently attained very considerable dimensions; from the fragments in the collection it can be judged that the colony, if entire, had a height of at least 150 to 200mm.

Locality and geological position.—The present species is entirely restricted to the middle division of the Productus-limestone, and has been found in several tolerably large fragments at Morah in the hard limestones which compose there the middle zone of that division.

Remarks.—If one takes only the non-poriferous side into consideration, then the *Pol. transiens* forms a member of a series of forms which commences with *Pol. sykesi*, Kon., proceeds by *Pol. ornata*, W. & P. and *Pol. koninckiana*, W. & P. and terminates with *Pol. megastoma*, Kon., in which series the *Pol. sykesi* is the form which possesses the smallest fenestrules and *Pol. megastoma* the one with the largest fenestrules. *Pol. transiens*, W. & P. would then hold a place between *Pol. koninckiana* and *Pol. megastoma*. It cannot be subject to much doubt, that all these forms are more or less related to each other; they are however not only different from each other in size, but when the poriferous side is also taken into consideration, one finds that the number of longitudinal rows of pores is different in the different species, and that also the arrangement of the pores is subject to great variation. The species here under consideration is distinct from all the rest by dissepiments, which are of the same breadth as the branches and bear pores nearly for their whole extent. At the same time the fenestrules are arranged more or less distinctly in quincunx, which causes a general appearance very much like that of *Phyllopora*. All these circumstances exhibit the present species as a sort of transitional form between the genera *Polypora* and *Phyllopora*.

What caused us rather to describe it as belonging to the former genus than to the latter was the distinct bifurcation of the branches, which is apparent at least in the lower parts of the colony, and the general occurrence of a space free from pores on the dissepiments.

Of non-Indian species there is none to which the present one could be more particularly compared.

Genus: PHYLLOPORA, King.

The materials of this genus preserved in the Salt-range collection are, we regret to say, very scanty, and it is with difficulty that we are able to distinguish the species which have been already described by Mons. de Koninck from the same ground.

As regards the forms which we believe should be ranked in this genus, we think they ought to exhibit the following characters.

The colony infundibuliform, with folded expansions at the margin composed of anastomosing tortuous branches joined together from distance to distance in such a manner that a compact shelly plate is formed, pierced by round or oval openings, and in which the branches can be traced only with great difficulty. The cells are in their position very characteristic: they ascend only for a very short distance along the basal-plate and then bend directly outward, thus becoming nearly vertical to it.

The basal-plate, which occupies the non-poriferous side of the colony, is mostly thick and composed of numerous fine capillary tubes. Its surface is either longitudinally striated or granulated.

The genus is distinct from *Fenestella* and its allies as well as from *Polypora* by the absence of dissepiments devoid of pores.

According to this diagnosis several specimens in the collection must be considered as belonging to the genus; they are however mostly only small fragments. Two of these forms can be united with species that have been already described by Mons. de Koninck, and a third one indicates the existence of a new species. The greater number and the best preserved specimens can be easily identified with *Phyllopora cribellum*, Kon. The identification of another small fragment with *Phyll. haimeana*, Kon. is not so certain. The third species is also represented only by a small fragment and will bear the name of *Phyllop. jabiensis*, W. & P.

Of these the two first named occur in the middle division of the Productus-limestone, whilst the third was found in the Cephalopoda-bed of the upper division.

None of these species has been found up to the present anywhere else in the world except in the Productus-limestone of the Salt-range.

1. PHYLLOPORA JABIENSIS, Waagen & Pichl., n. sp., Pl. XCII, fig. 1.

The shape of the colony cannot be made out, as only small fragments of the species exist.

These fragments consist of a tolerably coarse net-work composed of narrow branches which have the breadth of about 1 to 1½mm. They follow distinctly a zig-zag line, thus meeting each other and diverging again from distance to distance. They augment more or less rapidly in number by the intercalation of new branches, not by the bifurcation of the old ones. The new branches are in the beginning thinner than the old ones. At the junctions of the branches they are quite blended together. These connecting portions are broader than long and as broad or broader than the single branches; they form a kind of indistinct dissepiments. They are situated on the same level as the surface of the branches, and are, like the latter, entirely covered with pores.

The fenestrules are about 1½ to 2mm. long, oval, and always considerably longer than broad. They are very regularly arranged in quincunx, and there are generally four fenestrules in the longitudinal direction within the distance of 10mm. In the obliquely ascending rows, five fenestrules can be counted within the same distance.

On the poriferous side there are irregular tubercles distributed along the branches; they do not however interfere with the distribution of the pores. These pores are arranged in five to six longitudinal alternating rows, and thus are distributed regularly in quincunx. The obliquely ascending rows are also mostly composed of five to six pores.

The non-poriferous side is covered with very numerous and very fine longitudinal striæ which only with difficulty can be distinguished. From distance to distance little root-like prominences occur, which probably have served as a partial support to the colony.

Locality and geological position.—There is a single specimen of this species preserved in the collection. It was found in the Cephalopoda-bed of the upper division of the Productus-limestone of Jabi.

Remarks.—The present species has a rather near ally in the permo-carboniferous beds of Spitzbergen. This is *Phyllop. laubei*, Toula. The dimensions of the fenestrules as well as those of the branches are very similar in both forms; but Toula mentions only three rows of pores on the branches, whilst there are five to six such rows in *Phyllop. jabiensis*, and the tubercles with which the poriferous side is ornamented are irregularly distributed in the Indian species, whilst they form a regular row on the middle-line of the branches in *Phyllop. laubei*.

It is however on the whole not improbable that the *Phyllop. laubei* may have been the ancestor of our *Phyllop. jabiensis*, though the geographical occurrence of the two is so very different.

2. Phyllopora cribellum, Koninck, Pl. XCII, figs. 2, 3.

1863. *Phyllopora cribellum*, Koninck: Quart. Journ. Geol. Soc. Lond., vol. XIX, p. 6, pl. I, fig. 2.
1863. *Phyllopora? cribellum*, Koninck: Foss. Paléoz. de l'Inde, p. 19, pl. I, fig. 2.

The colony consists of a thin calcareous plate, having on the whole an infundibuliform shape, with somewhat waving peripheral parts. At its lower extremity the colony terminates in a thick short calcareous stem which is very compact and on which even the fenestrules are partly obliterated.

The remaining part of the colony is pierced by numerous round holes, and neither branches nor dissepiments can be distinguished on the non-poriferous side. This latter is the outer one, whilst the pores are distributed on the inner side of the funnel. The round holes or fenestrules are arranged very distinctly in quincunx, whereby obliquely ascending intersecting rows are formed. Within these oblique rows eight such fenestrules can be counted, in a length of 10mm.

On the poriferous side, on the contrary, the branches can very distinctly be made out. They are about 1mm. broad, anastomosing from distance to distance, but as they are joined together only by their lateral portions, they can be followed out forming waving lines, bending to and fro. The fenestrules, which are produced in this way, are elongately oval or lozenge-shaped and appear rather smaller than on the other side. The branches can also be distinctly seen here to augment by bifur-

cation and not by intercalation. On this side longitudinal as well as oblique rows of fenestrules can be made out. In the longitudinal rows only six fenestrules can be counted within the distance of 10mm., while in the oblique rows, as on the other side, eight fenestrules occur within the same distance. The cause is, that the parts connecting the branches are broader than the branches themselves and at the same time distinctly excavated, whereby it happens that the branches appear so well separated from each other.

The comparatively large cell-openings are of an oval-shape and do not project above the surface of the branches. The cells themselves are vertical to this same surface. There can be counted four to five longitudinal alternating rows of pores; they cover all the internal face of the funnel-shaped colony without leaving any space free of pores where the branches are joined laterally together.

On the non-poriferous side the fenestrules appear, as has been stated above, as nearly circular holes. The surface of this side is composed of very numerous and exceedingly fine capillary tubes. If the outer coating is entirely well preserved, the whole surface is covered by a fine but very distinct granulation.

The species seems to have attained only a very moderate size. There is one nearly entire specimen preserved in the collection, and its height is not more than about 30mm., while the breadth at the upper end of the funnel can barely have ever been more than 50mm.

Locality and geological position.—There are only two specimens of this species preserved, one of which was found in the Cephalopoda-bed of the upper Productus-limestone at Jabi, while the other comes from the middle region of the middle Productus-limestone of Morah.

Remarks.—The present species was originally described by Koninck only from the non-poriferous side, and thus in looking through the Salt-range materials it was necessary first to find out specimens which would on their non-poriferous side be identical with Mons. de Koninck's drawings and description. This has been secured with the specimens figured by us on Pl. XCII; and it needs only a comparison of these figures with Koninck's drawing to become convinced of the matter. Only afterwards was the poriferous side made visible, and it was found that this side was very unexpectedly similar to a species figured by M'Coy from the carboniferous-limestone of Ireland. This is *Retepora undata*, M'Coy, which in its general appearance and the arrangement of the fenestrules and pores appears very nearly related to *Phyllopora cribellum*, but is distinct from it by its much larger size and less numerous pores.

3. Phyllopora haimeana, Koninck, Pl. XCV, fig. 1, ? Pl. XCI, fig. 7.

1863. *Phyllopora? haimeana*, Koninck: Quart. Journ. Geol. Soc. Lond., vol. XIX, p. 6, pl. I, fig. 3.
1863. *Phyllopora jonesiana*, Koninck: Foss. Paléoz. de l'Inde, p. 19, pl. I, fig. 3.

There are apparently no materials at all in the Salt-range collection which can without hesitation be assigned to this species of Mons. de Koninck's. Perhaps the

specimen figured by us, Pl. XCI, fig. 7, might be placed in the species, but as the specimen is such a very small fragment and of such a singular hemispherical shape, we could not be sure of the matter.

We shall thus restrict ourselves to reproduce Mons. de Koninck's description of the original specimen and then add a description of the doubtful specimen which may perhaps represent the species in the Salt-range collection.

Mons. de Koninck describes his *Phyllop. haimeana* in the following manner: "The calcareous plate of this species is rather thicker than that of *Phyllop. cribellum*, but its shape is almost the same. The openings, with which it is covered, are much larger; they are circular, and also somewhat funnel-shaped. Their disposition is much less regularly quincuncial; one can count but four or five every centimetre. Only a single specimen is known." To complete this description we have given a copy of Mons. de Koninck's original drawing on Pl. XCV, fig. 1.

It is evident that in the specimen which served for description, the non-poriferous side only was exposed to view. If we compare now our specimen from the Salt-range with Mons. de Koninck's description and figure, we find that though the dimensions are not exactly the same, yet they are very nearly so, and as also the other characters are very similar, we thought it most probable that this small specimen might belong to Koninck's species.

The whole specimen forms a tolerably thick shelly plate which is bent in such a way as to present a hemispherical outline. This plate is pierced by rather numerous circular or slightly oval holes, which are distinctly funnel-shaped on the non-poriferous side. These holes on the non-poriferous side have on an average a diameter of about 1 to 1½mm. while the spaces between are always at least 1½mm. broad. No branches or dissepiments can be distinguished. Of the holes or fenestrules at least five can be counted within a length of 10mm. They are arranged somewhat irregularly in quincunx, and obliquely ascending rows can be made out only with difficulty.

The shelly spaces between the fenestrules are well vaulted and their surface, if looked at with a lens, seems to be provided with many irregular shallow pores or something like pores, probably an effect of weathering.

The poriferous side, which it was very difficult to expose to view, is in its general appearance very similar to the non-poriferous one. The branches are perhaps a little more distinguishable than on the other side. They appear rather broad and bending laterally to and fro, uniting and disuniting again, and thus forming fenestrules of an elongately oval shape, which however appear not much smaller than on the non-poriferous side. Their arrangement is on both sides identical. The branches are covered with numerous cell-openings which are distinctly arranged in quincunx and form about four to five longitudinal alternating rows. On the whole poriferous side there is not the smallest space free from pores. The pores themselves are round and tolerably large; their margins are not raised above the surface of the branches.

As to the size of this species, nothing can be indicated, as only small fragments of the colony have been found up to the present.

Locality and geological position.—The only small fragment that might be assigned to this species was found in the middle division of the Productus-limestone at Morah. From what special locality the specimen described by Mons. de Koninck was procured is not known.

Remarks.—If one takes only Mons. de Koninck's drawing into consideration, then the species has a very peculiar appearance and can be easily distinguished from the other species occurring in the Salt-range. If, however, our fragment may be taken as belonging to *Phyllop. haimeana*, then the species no longer appears to hold such a separate position, but can well be compared to other species chiefly to the *Phyllop. jabiensis* described above.

From this last-named species the present one can be distinguished by fenestrules which appear much rounder, not so oval on the non-poriferous side, and arranged at the same time much less regularly in quincunx. On the poriferous side the branches are devoid of the tubercles which constitute such a characteristic ornamentation of *Phyllop. jabiensis*, and bear also a somewhat smaller number of pores. These characters seem sufficient for the distinction of the two species.

From *Phyllop. laubei*, Toula, which is also related to *Phyllop. jabiensis*, and which thus might also be compared to the present species, the latter can be distinguished by the absence of an ornamentation on the poriferous side of the branches and by more numerous pores, as in the species from Spitzbergen only three longitudinal rows exist.

Phyllop. cribellum, Kon., can easily be distinguished by the much smaller fenestrules and the entirely different poriferous side, in which the branches can easily be made out.

Genus: SYNOCLADIA, King.

This genus is represented in the Salt-range by very numerous individuals, which belong however all to one and the same species.

The genus is always very easily recognisable. It forms generally infundibuliform colonies composed of numerous branches, which take their origin at a small root-like organ, extend nearly parallel to each other and bifurcate at intervals. On both sides of the branches, numerous small branchlets originate, extending obliquely upward and uniting from both sides under an obtuse angle. These angles of the dissepiments are often connected by vertically ascending pieces, forming narrow secondary branches.

The pores are distributed on the internal side of the funnel-shaped colony, and the dissepiments as well as the branches are covered with them. They are arranged in an imbricating manner, and are separated from each other in the longitudinal direction by prominent ridges which sometimes bear secondary pores (the gemmuliferous vesicles of King).

Though this genus is very easily distinguishable from all the other genera of the *Fenestellidæ* yet it has not always been rightly interpreted. Thus, for instance, the form described by Meek under the name of *Synocladia biserialis* seems not to belong to the genus, but must rather be united with the genus *Septopora* of Prout. On account of the genus having sometimes been mistaken, it is difficult to indicate its geographical distribution and geological range.

In America the genus seems, so far as we are aware, not to occur at all. In the eastern hemisphere, on the contrary, it is very plentifully represented, but seems to be restricted to the permian formation, and seems never to have been correctly quoted from carboniferous strata.

As regards species, it must be confessed, that the genus is very poor. Also we are not in a position to add a new species to the one already known, as in the Salt-range only the characteristic permian species *Synocladia virgulacea* occurs.

It has been found not rarely in the middle as well as in the upper division of the Productus-limestone.

1. SYNOCLADIA VIRGULACEA, Phill. sp., Pl. XCII, fig. 4; Pl. XCIII, figs. 1, 2, ? Pl. XC, fig. 8.

1829. *Retepora virgulacea*, Phillips: Trans. Geol. Soc. Lond., 2nd ser., vol III, p. 120, pl. XII, fig. 6.
1834. *Retepora virgulacea*, Phillips: Encycl. Met., vol. VI, p. 615, pl. III, fig. 2.
1845. *Fenestella virgulacea*, (Phill.) Verneuil: Murch. Vern. Kays., Geol. of Russia, p. 221.
1850. *Synocladia virgulacea*, (Phill.) King: Monogr. Brit. Perm. Foss., p. 39, pl. III, fig. 14, pl. IV, figs. 1—8.
1855. *Synocladia virgulacea*, (Phill.) M'Coy: Brit. Palæoz. Foss., 115.
1861. *Synocladia virgulacea*, (Phill.) Geinitz: Dyas, p. 118, pl. XXII, figs. 3, 4.
1863. *Retepora? lepida*, Koninck: Quart. Journ. Geol. Soc. Lond., Vol. XIX, p. 6, pl. I, fig. 5.
1863. *Retepora? lepida*, Koninck: Foss. Paléoz. de l'Inde, p. 19, pl. I, fig. 5.

The colony is infundibuliform, often irregularly folded and very variable in respect of the strength of the branches and the shape and size of the fenestrules.

The branches in different specimens, and even in one and the same specimen, are sometimes thicker sometimes thinner, but the difference is not very great. They originate from a thin root, bifurcate frequently, augmenting somewhat in thickness just before the bifurcation takes place, and extend either quite straight and parallel to each other to the periphery of the colony or, in folded specimens, they are slightly curved. They sometimes approach very close to each other, sometimes there is a greater space between them.

The dissepiments are sometimes very short, sometimes rather long, according to the distance between the branches. They are united to the branches under a more or less acute angle, and form in the middle either an obtuse angle or a broad arch. When the distance between the branches is very small, the dissepiments are quite straight. They are always much thinner than the branches, and on both sides of the colony they lie at a lower level than the surface of the branches. In the middle, where the angle is formed, a process often arises and sometimes unites with

the next dissepiment, and so on, so that a kind of secondary branches are thus formed. These are always much thinner and situated on a lower level than the main branches, and disappear again after a short distance.

The fenestrules occurring between the branches and the dissepiments are correspondingly variable; sometimes they are large or small; sometimes long and more or less trapezoidal, or short and very broad, or in other cases the shape may be oval or nearly circular, or quite irregularly polygonal. Their margins sometimes appear denticulated. There are in the longitudinal direction nine to eleven fenestrules within a length of 10mm. while in the transverse direction five to seven rows can be counted within the same distance.

The cells are more or less tubular or pyriform, placed obliquely to the axis of the branches, and arranged in an imbricating manner. The cell-openings are round with slightly raised margin. They form three or five alternating longitudinal rows on the branches, separated from each other by slightly raised undulating keels, on the top of which, under favourable circumstances, very small accessory pores, placed alternately with the larger cell-openings, can be distinguished. The cells extend also upon the dissepiments in two to three irregular rows of pores, so that no space remains free of pores.

The non-poriferous side is in general appearance not much different from the poriferous one. Its surface is finely striated longitudinally.

From King's drawings it is known that the species attained rather considerable dimensions. The Indian materials consist of mere fragments of the colonies and do not allow of any conclusion as to the size the entire colonies once attained.

Locality and geological position.—The present species is one of those *Bryozoa* which occur most commonly in the Salt-range; in fact it may be termed the commonest species. It occurs in the middle division as well as in the upper division of the Productus-limestone, and is in both divisions about equally common.

In the middle division it has been found at Morah (2 sp.) at Kàfirkot (1 sp.) and at the Paranga Kass (1 sp.).

In the upper division it has been met with in the lowest beds at Khura (2 sp.) and in the Cephalopoda-bed at Jabi (2 sp.) and at Chidru (2 sp).

Remarks.—It is well known that the present species is one of the most characteristic and most widely spread species of the permian formation. It has been found in the Zechstein of Germany and in the magnesian-limestone of England as well as in the permian beds of Russia.

As regards the determination of our Indian specimens, it seems to us that it needs only a comparison of the figures given by King or Geinitz with those on our plates XCII and XCIII to become convinced of the specific identity. The very slight discrepancies which might perhaps be detected arise certainly only from the mode of preservation of the Indian specimens, which are either in great part silicified, or entirely calcareous, and then often so much weather-worn that the thickness of the branches dwindles down to mere threads.

A specimen preserved in such fashion is that figured by Mons. de Koninck under the name of *Retepora ? lepida*. We are perfectly convinced that the figure given by Mons. de Koninck represents a weather-worn specimen of *Synocladia virgulacea*, and we have accordingly placed Mons. de Koninck's name *Retepora lepida* in the synonymy of the species. As the original of Mons. de Koninck's species has been lost, one can only judge by the figure.

The specimen, figured on pl. XC, fig. 8, is preserved in a rock fragment from Jabi, but we do not exactly know how to determine it. It seems probable that it belongs to the genus *Synocladia*, and it might be considered as a very young colony of *Synocladia virgulacea*, but we are not certain of it. The fragment is too small to express any more definite opinion on it.

The occurrence of this well-known and very characteristic permian species in the Productus-limestone of the Salt-range confirms once more our opinion already expressed, that the middle and upper divisions of the Productus-limestone must be considered as most probably equivalent of the permian formation of Europe.

Sub-family: *GONIOCLADINÆ.*

Genus: GONIOCLADIA, R. Etheridge, jun.

This genus was originally (1873) described by Etheridge under the name of *Carinella*, a name that has been accepted in Zittel's Hand-book. Afterwards however, in the year 1876, Mr. Etheridge found that the name *Carinella* had been previously used for a genus of Annelids, and accordingly he changed it into *Goniocladia*.

The colonies belonging to this genus consist of irregularly bending, anastomosing branches, which form thus a confused net-work. The branches are provided on the poriferous as well as on the non-poriferous side with a strongly prominent median keel, on both sides of which, or the poriferous side, the cell-openings are distributed. The branches seem all to rise from a common root, and augment by indistinct bifurcation. The whole colony seems to have been leaf- or fan-shaped.

By the anastomosis of the branches rather large meshes are produced, which are either of pentagonal or hexagonal or of an irregularly polygonal outline. The keel on both sides of the branches, following every bend of the latter, surrounds the meshes on all sides, and as also the pores are everywhere present on the poriferous side, it becomes impossible to distinguish between branches and dissepiments.

From all these characters it results that the general appearance of the genus becomes most striking, and one which can be distinguished at a first glance from all the rest of the *Fenestellidæ*. It unites, if we may say so, the characters of the *Fenestellinæ* and the *Polyporinæ*, and is distinct from both by the very loose net-work, and the strongly carinated non-poriferous side.

Most nearly related to the present genus seems to be the genus *Ramipora* of Toula, in which the branches are also carinated on both sides. The ramification of

Ramipora is however entirely different from that of *Goniocladia*, and thus the two genera can easily be distinguished.

Of the genus *Goniocladia*, only a single species has up to the present been described, it was found in the carboniferous beds of Carluke. We are able to add another species, which will bear the name of *Goniocladia indica*, W. and P., from the middle division of the Productus-limestone. It thus appears probable that it is of permian age.

1. Goniocladia indica, Waagen and Pichl, Pl. XCIII, fig. 3.

The colony forms fan- or leaf-shaped, flatly folded expansions, composed of an irregular loose net-work.

The branches forming the net-work are frequently and angularly bent, but the way in which they divide and again re-unite is so irregular that it is quite impossible to follow one branch for any distance. For the same reason it is also impossible to distinguish between branches and dissepiments. Sometimes it appears as if a rather irregular dichotomous branching could be made out, but soon the branches are lost again in the general net-work. Sometimes a single branch originates on the broader of one of the meshes and forms a little prominence not again connected with the net-work. The breadth of the branches is about 1½mm. They are strongly compressed laterally, and provided on the poriferous as well as on the non-poriferous side with a high keel, from which on both sides the surface descends rapidly, giving to it a roof-shaped appearance. This keel takes part in all the branchings of the net-work, and appears generally somewhat stronger on the non-poriferous than on the poriferous side. On the former it appears in well preserved specimens as a high edge, which is supported interiorly, as can be seen in weathered places, by a vertical lamella, on both sides of which the cells take their origin. On the poriferous side on the contrary it is mostly more rounded and less prominent, but here also generally a lamella runs along it.

The fenestrules or meshes of the net-work are comparatively large and of very irregular outline, mostly longer than wide. Their length varies from three to seven millimetres while their breadth is from 1 to 4mm. They are either lozenge-shaped or pentagonal, hexagonal or else irregularly polygonal. Their margins are sometimes slightly indented by the projecting cell-apertures; sometimes however they are quite smooth.

The pores or cell-apertures are distributed on the poriferous side on both sides of the median keel. They are round with slightly projecting margins and form on each side of the keel three alternating rows, the lowest of which is placed very far towards the non-poriferous side. The whole obverse side of the colony is occupied by these pores, and they are to be found on the branches as well as on the places where the branches unite.

The non-poriferous side is occupied by a very thin basal-plate, which, if well preserved, shows a fine longitudinal striation. This is however very easily lost, and

even the basal-plate itself, on account of its thinness, is easily destroyed, and then the origin of the cells on both sides of a median lamella can be well observed (Pl. XCIII, fig. 3e.).

The single specimen preserved in the Salt-range collection does not allow any conclusion as to the size the entire colony may have attained.

Locality and geological position.—There is a single specimen of this species preserved in the Salt-range collection. It was found at Káfirkot in the middle region of the middle division of the Productus-limestone.

Remarks.—As only a single species of *Goniocladia* has up to the present been described, it needs but a comparison of the Indian fossil with this species to judge of its specific affinities. It cannot be denied that the Indian specimen shows great similarity to *Goniocl. cellulifera*, Eth., and for a long time we were very much in doubt whether the two forms should not be united, but after a lengthened consideration we came to the conclusion that the Indian fossil belonged probably to a different species. The chief difference seems to consist in the mode of ramification; in the European species the branches can be followed to some extent while this is quite impossible in the species here under description. Also the branches are somewhat thicker and the fenestrules larger, and the keel on the non-poriferous side stronger in our *Goniocladia indica*. Since these differences occur in fossils so very far removed from each other, geographically as well as geologically, it seemed to us highly probable that the Indian fossil belonged to a different species from the European one, and we accordingly have introduced a new name for it.

Family: THAMNISCIDÆ.

This family was created by Mr. King to receive certain arborescent colonies of *Bryozoa*, the branches of which are all about in one plane, and the cell-openings occur only on one side of the branches. The genus *Thamniscus*, King, had been taken as the type of the family.

Though Mr. Zittel in his Hand-book accepts nearly the same groupment of the genera as proposed by King, yet he could not retain the name *Thamniscidæ*, as he considered *Thamniscus* identical with *Acanthocladia*, and therefore changed the name into *Acanthocladidæ*.

We cannot agree in this respect with Prof. Zittel, not only because the name *Thamniscidæ* is the older one, but also because it seems to us that the genus *Thamniscus* can very well be kept separate from *Acanthocladia*, and thus entirely disappears the reason on account of which the name was changed by Zittel. We therefore accept King's name for the family.

There is barely anything to be added to King's excellent characteristic of the family. The *Bryozoa* belonging to it form arborescent colonies, which consist of one or several primary branches, from which on both sides secondary branches take their origin; these however always remain free and are never connected by dissepi-

ments or otherwise as is the case in the family *Fenestellidæ*. All these branches are situated in one plane.

The internal structure is similar to that of the *Fenestellidæ*. The cells take their origin at the basal-plate, which occupies the non-poriferous side of the colony; thence they ascend, arranged in an imbricating manner, and their openings are to be found on the poriferous side, where they form two or more longitudinal rows of pores.

The number of genera belonging to this family is not very large, nevertheless it might be possible to distinguish sub-families, as has been done in the family *Fenestellidæ*. The materials in our hands are however too scanty to express a definite opinion in this respect, and we must leave the solution of this question to later observers.

Zittel in his Hand-book quotes in the present family the genera *Acanthocladia*, King, *Pseudohornera*, F. Roem, *Penniretepora*, Orb. (= *Glauconome*, Lonsd.) and *Ichthyorhachis*, M. Coy. To these must be added *Thamniscus*, King, which has been united by Zittel with *Acanthocladia*.

In the Salt-range the two genera *Thamniscus* and *Acanthocladia* are represented, the former by two and the latter by one species.

Genus: THAMNISCUS, King.

The genus was founded upon the comparatively large and robust *Thamn. dubius* from the permian beds of Europe, and only such forms as agree in all respects with this permian fossil should be united with the genus.

A characteristic of the genus from this typical permian species is as follows: The colony is composed of numerous comparatively stout branches, which frequently bifurcate, the bifurcation being always terminal and mostly unilateral, so that only one of the newly-formed branches (nearly always directed towards the same side) goes on augmenting in size and again bifurcating. All the branches are approximately in one plane, and all are of about equal strength. The branches are covered with cell-openings only on one side, the other side is non-poriferous. The cell-openings are arranged more or less regularly in quincunx, and between them sometimes so called gemmuliferous vesicles are distributed.

According to King and Geinitz an anastomosis of the branchlets may sometimes occur, so as to form fenestrules similar to those occurring in Synocladia. The occurrence of such fenestrules has however been doubted recently by Shrubsole, and we must confess that we also have not been able to observe such an anastomosis in the specimens at our disposal.

The character which distinguishes the present genus from the other allied ones consists then in the quite peculiar ramification, which is irregularly terminal, dichotomous, and mostly one-sided.

The distinctness of the genus has however not been always recognised. Zittel in his Hand-book unites it with *Acanthocladia*. This is evidently a mistake caused

by the misapprehension that the distinction of *Thamniscus* and *Acanthocladia* was founded upon the arrangement of the pores, which is said to be quincuncial in the one case and in rows in the other. From what has been said above however, it appears that the distinction of the two genera rests chiefly in the ramification of the whole colony, which is so very different in the two cases that a distinction becomes most easy.

The genus has its geological distribution chiefly in the permian formation, where the typical species was found. More recently species have also been quoted from carboniferous as well as from silurian formations. For the silurian forms however, which were originally quoted by Lonsdale under the generic designation of *Hornera*, the name of *Pseudohornera* has been introduced by F. Roemer. This *Pseudohornera* is distinct from *Thamniscus* by the much thinner branches, which bifurcate less frequently and more regularly than in *Thamniscus*, and show rather a bilateral than a unilateral branching. If then the silurian species must be considered as belonging very probably to a different genus, it is so also with the carboniferous *Thamniscus rankini*, Young, which differs by the same characters from *Thamniscus* as the silurian *Pseudohornera crassa*, Lonsd. Thus only the permian *Thamniscus dubius* would remain in the genus, and the genus would be restricted to the permian formation, unless *Thamniscus bifidus*, Eichw. makes an exception, as it is said to be from the silurian Orthoceras-limestone. It is however well known how little the stratigraphical indications in Eichwald's work can be trusted.

In the Salt-range the genus is represented by two highly interesting species. One of them can be directly identified with the permian *Thamniscus dubius* and is thus of much geological interest; the other is a large species with regularly arranged cell-apertures; it augments by one the number of permian species of *Thamniscus*.

Both these Salt-range species occur in the middle division of the Productus-limestone, the latter however extends also into the upper division.

THAMNISCUS DUBIUS, Schloth, sp., Pl. XCIII. fig. 4.

1820. *Keratophytes dubius*, Schlotheim: Petrefaktenkunde, p. 340.
1826. *Gorgonia dubia* (Schloth. sp.) Goldfuss: Petref. Germ., Vol. I, p. 18, pl. 7, fig. 1.
1844. *Fenestella ramosa* et *dubia*, King: Bull. Soc. Geol. de France, I, p. 24, 25.
1850. *Thamniscus dubius* (Schloth. sp.) King: Monogr. Brit. Perm. Foss., p. 44, pl. 5, fig. 7—12.
1850. *Penniretepora dubia* (Schloth. sp.) d'Orbigny: Prodr. de Pal. strat., I, p. 169 (pars).
1853. *Thamniscus dubius* (Schloth.) Schauroth: Sitzgsber. Acad. d. W. Wien, Vol. XI, p. 184, fig. 23.
1858. *Thamniscus dubius* (Schloth.) Swallow and Hawn: The rocks of Kansas; Trans. St. Louis Acad. of Sci., Vol. I, Nr. 2, p. 179.
1861. *Acanthocladia dubia* (Schloth.) Geinitz: Dyas, p. 119, pl. XXII, fig. 5, 6.
1882. *Thamniscus dubius* (Schloth.) Shrubsole: Quart. Journ. Geol. Soc. Lond., Vol. XXXVIII, p. 343.

We have given in the above list only some of the quotations which seemed to us of importance for the right understanding of the specific characters. The full list of synonyms is to be found in Geinitz's Dyas.

The colony forms arborescent expansions made up of numerous branches having an average thickness of 1 to 1½mm. These branches bifurcate frequently and irregularly in such a manner that the lateral branches are of the same strength as the primary ones, and are directed almost all to one and the same side. Both surfaces of the branches are flatly vaulted.

The cell-openings are all to be found on one side only of the branches. They form little round pores, the margins of which are somewhat raised, and rather far distant from each other, leaving a distance between them which is often nearly twice as large as the pores themselves. When the surface of the branches is more or less weathered, the pores appear much larger, much closer together, and more or less lozenge-shaped.

The arrangement of the pores is generally more or less regularly in quincunx, in three to six alternating longitudinal rows. Gemmuliferous vesicles, as they have been called by King, have not been observed in the Indian specimens.

The non-poriferous side is apparently smooth.

From the somewhat fragmentary specimens of the Salt-range, nothing can be judged as to the size the species may have attained, and it would seem from European specimens that the size was never very considerable.

Locality and geological position.—There are altogether only two not very extensive fragments of this species preserved in the Salt-range collection, which are both contained in a slab of rusty-coloured limestone, collected by Mr. Wynne at Morah in the middle region of the middle Productus-limestone. On the same slab specimens of *Phyllopora cribellum* Kon. and *Acanthocladia anceps* Schl. are to be observed.

Remarks.—The specimens from the Salt-range that have served us for description of the species are on the whole not very well preserved, as the greater part of the surface is much deteriorated by weathering. Yet there is sufficient to allow of an exact determination, whereby we can safely identify the Indian specimens with *Thamniscus dubius*, Schloth.

The ramification of the branches is about the same, though in these not very extensive fragments this can only be judged on a small scale. The thickness of the branches and the distribution of the pores on the well preserved parts of the surface are absolutely identical, and on the whole it seems to us impossible to determine these fragments otherwise than as *Thamniscus dubius*, Schloth. Large specimens however will have to be discovered before every doubt with regard to this species can be removed.

Nevertheless the correctness of our determination is highly probable, and the geological importance of the occurrence of a species not distinguishable from *Thamniscus dubius* in the Productus-limestone of the Salt-range is not much altered by the fact that only comparatively small fragments have been found up to the present, as it is highly probable that large specimens will also agree with the European permian species.

The occurrence of this species on the same slab with *Acanthocladia anceps*, Schloth., another permian species that will be described in the following pages, gives so much the more value to the determination of *Thamniscus dubius*. The list of permian fossils occurring in the Salt-range, which is already rather considerable, is thus augmented by one.

Thamniscus dubius is one of the most characteristic and most wide-spread species of the permian formation. It has not only been found in the "Zechstien" of Central Europe, but also most commonly in the permian beds of the British Isles, and in the same beds at Cotton-wood Creek in Kansas. Since the detection of the Indian localities it would seem that the species spread over the whole world.

2. THAMNISCUS SERIALIS, Waagen and Pichl, n. sp., Pl. XCIV, fig. 4, 5, 6.

The colony forms arborescent flattened expansions composed of numerous ramifying branches. These are generally about 2mm. in width, with the surface flatly vaulted; they bifurcate frequently, at intervals of about 5 to 10mm. The lateral branches thus formed are about of the same strength as the principal stems; they are mostly all directed towards the same side, and bend quickly upward, following about the same direction as the principal stems. Just before the bifurcation takes place the stems are generally somewhat thickened.

The numerous tubular cells, occupying nearly the whole breadth of the branches, ascend obliquely and are arranged in an imbricating manner. The openings have strongly raised margins, especially those having more a lateral direction project far above the surface of the branches. Several of these cell-openings are joined together laterally and thus form ridges starting from the median parts of the branches and extending in an oblique direction towards the margins; the pores are situated along the top of these ridges. The very characteristic sculpturing thus produced is not however connected with any structural peculiarity as can be seen in weathered specimens in which those oblique ridges disappear. In such specimens the pores form seven alternating longitudinal rows, whereby a distinct quincuncial arrangement is produced, so that oblique intersecting rows of pores are as easily distinguishable as in any *Polypora*. On unweathered parts of the branches, only the three median longitudinal rows of pores can distinctly and easily be made out as in a quincuncial position.

The non-poriferous side is occupied by a very thick stony basal-plate. It is very indistinctly striated longitudinally, almost smooth, and pierced at intervals by very small pores.

The species seems to have attained rather considerable dimensions, and to have varied slightly according to age; at least we notice that some of the specimens at our disposal branch more frequently than others. It is probable that the former represent the lower or older parts of the colony.

Locality and geological position.—There are altogether three specimens of this species in the Salt-range collection. The one most beautifully preserved was found

by Mr. Wynne, at Morah, in the middle region of the middle Productus-limestone. It forms a rather large arborescent expansion, in which the singular ramification of the species can be well studied. The other two specimens are smaller fragments and were both collected at Khura in the lower beds of the upper Productus-limestone.

Remarks.—The present species has in its outward appearance a certain similarity to *Idmonea*, and we for a time thought that it should perhaps be placed in that genus; but after a careful examination of our specimens, we found that they had in reality much more affinity to *Thamniscus* than to *Idmonea* as the bilateral sculpturing of the branches is only an external feature and not caused by a peculiar arrangement of the cells, and as the median dividing edge characteristic of *Idmonea* is altogether wanting. After having thus settled the generic relations there remained no doubt that the specific characters were very peculiar, making a distinction from all the other species of *Thamniscus* hitherto described most easy. There is a single species with a similar number of longitudinal rows of pores and similarly robust branches, and this is *Thamniscus bifidus*, Eichw. This species is quoted by Eichwald as coming from the silurian *Orthoceras*-limestone of Russia, but it seems to represent a true *Thamniscus*. From what has been said in the introduction to the genus it might perhaps be doubted whether this species really came from those beds, as in silurian strata the genus *Thamniscus* seems to be generally absent and to be replaced by the genus *Pseudohornera*, Roem. However this may be, the species *Thamn. bifidus* can only with difficulty be compared to our *Thamniscus serialis*, as of the former only the non-poriferous side is figured, and of the poriferous side nothing is stated but that about seven longitudinal rows of pores can be counted.

The evidence before us is much against the probability of the two species being identical, and thus we have ventured to introduce a new name for the Indian form.

Genus: ACANTHOCLADIA, King.

The genus *Acanthocladia* is made up of a very small number of species, of which the permian *Acanthocladia anceps* is the most common and at the same time the best known.

It has already been stated that this genus has sometimes been united with *Thamniscus*, King. As this proceeding is however entirely erroneous, it may not be superfluous here again to repeat the generic diagnosis of *Acanthocladia*.

The colony is arborescent, composed of a few not frequently dividing branches, which all extend in about one and the same plane. The principal branches of the colony are mostly rather straight, and show from distance to distance a usually terminal bifurcation in which the two newly formed branches deviate equally from the original direction of the branch, or the principal branch remains in its original direction and a lateral branch sets off from it.

All the principal stems of which the colony is thus composed are furnished on both sides with little branchlets which are much narrower than the principal stems,

and never attain a very considerable length. They are about parallel with each other, always quite free, never joined together, and give to the principal stems a pinnate appearance. Their position is mostly alternating on the two sides, and they are generally of about equal thickness for their whole length and truncated at the extremity.

One side only of the colony is poriferous, and on this side the pores cover the lateral branchlets as well as the principal stems. The pores form mostly alternating longitudinal rows, which are more or less distinct. Often, it seems, the rows are separated from each other by longitudinal ridges on which very small pores (the gemmuliferous vesicles of King) are situated.

The non-poriferous side is for the most part finely striated longitudinally.

From this description it already most clearly appears that the chief difference between *Acanthocladia* and *Thamniscus* consists in the modes of ramification. In *Thamniscus* there is no distinction between stems and branchlets, as all the branches are of about equal thickness and are produced by bifurcation. In *Acanthocladia*, on the contrary, only the principal stems can be compared to the branches of *Thamniscus*, while the branchlets are organs which are restricted to the genus *Acanthocladia* and do not occur in *Thamniscus*. This occurrence of branchlets by which the stems acquire a pinnate appearance is a very peculiar character and makes the distinction of the two genera not only easy but absolutely necessary.

In the Salt-range we have found only a single species of *Acanthocladia*, which is however so much the more interesting as it can be identified with the permian *Acanthocladia anceps*, Schloth.

It was found in the middle region of the middle Productus-limestone.

Acanthocladia anceps, Schloth., sp., Pl. XCIV, figs. 1, 2, 3.

1820. *Keratophytes anceps*, Schlotheim: Petrefaktenkunde, p. 341.
1826. *Gorgonia anceps* (Schloth.) Goldfuss: Petref. germ., I, p. 98, pl. 36, fig. 1.
1842. *Eschara philippii*, Althaus: Münster's Beitr., V, p. 52.
1848. *Fenestella anceps* (Schloth.) Geinitz: Deutsch. Zechst., p. 18, pl. 7, figs. 19-23.
1850. *Acanthocladia anceps* (Schloth.) King: Monogr. Brit. Perm. Foss., p. 48, pl. 5, figs. 13-18.
1850. *Penniretepora geinitzi*, Ichthyorachis anceps and Ichthyorachis Geinitzi, D'Orbigny: Prodrome, I, p. 169.
1851. *Acanthocladia anceps* (Schloth.) Grünewaldt: De petref. form. calc. cupr., pp. 36, 45.
1861. *Acanthocladia anceps* (Schloth.) Geinitz: Dyas, p. 119, pl. XXII, figs. 7-8.
1881. *Acanthocladia anceps* (Schloth.) Quenstedt: Petrefaktenk. Deutschlands, vol. IV, p. 163, pl. 149, figs. 26-27.

The colony is composed of several slender erect branches, which rise from a common root and bifurcate frequently in the vicinity of this root, while further on the bifurcation takes place only rarely and at great distances. The branches are considerably thicker near the base than further on; at the root the thickness can be estimated at a little less than two millimetres while further on it is on an average 1 to 1½mm.

These principal branches or stems send off on both sides little branchlets, which are only about half the thickness of the stems, remain generally short, are but little tapering, and truncated at their extremity. They are situated either opposite or alternating along the sides of the stems and remain nearly always simple, only in rare cases sending off lateral branchlets. Their number and distance from each other is rather variable; there can be counted from five to ten within a length of 10mm. Generally they are directed somewhat towards the front, forming more or less acute angles with the principal stem. Sometimes however they are placed nearly at right angles with the principal stems. These branchlets give a distinctly pinnate aspect to the whole colony.

The surface of the stems is flatly vaulted on both sides, and bears on one side the comparatively small cell-openings. These form round pores with slightly projecting margins; they are arranged generally in three alternating longitudinal rows, but in exceptional cases up to six such rows may occur. As the rows alternate, the pores show also a more or less regular quincuncial arrangement. In well preserved specimens there extend between the longitudinal rows low strips on which very small pores are distributed. These must very likely be taken to represent the gemmuliferous vesicles of King.

The non-poriferous side is either smooth or shows a very fine longitudinal striation.

The species seems to have attained rather considerable dimensions, as branches of about 30mm. length are not rare. The maximum size may have been about 100mm.

Locality and geological position.—There are several more or less extensive fragments of this species in the Salt-range collection, all occurring on one slab of rusty brown limestone, which contains also the specimens of *Thamniscus dubius*, Schl., and *Phyllopora cribellum*, Kon., described above. The slab was collected by Mr. Wynne at Morah in the middle region of the middle Productus-limestone.

Remarks.—Though the fragments of this species are not very extensive and their preservation is not excellent, yet it seems to us that they can safely be identified with Schlotheim's species. The fragments are all from rather low down in the colony, especially the fragment represented in fig. 2 Pl. XCIV, which is broken just above the root. This may quite suffice to explain the slightly more robust condition of the Indian specimens and the somewhat more irregular ramification than is generally observed in European specimens of the species. That the species is rather variable in Europe also is sufficiently shown by King's drawings. The Indian specimens hold about a medium between figs. 13 and 14 on King's pl. V. On the whole, we think, the determination of these fossils as *Acanthocladia anceps*, Schl., cannot be subject to much doubt.

The species is one of the most characteristic and most wide-spread of the permian formation. In Central Europe it occurs sparingly already in the "Kupferschiefer," and is very common in the Zechstein, quite as common is it too in the Magnesian-

limestone of England. From the permian beds of Russia it has also been quoted, and in America either the same species occurs in the permian strata of Kansas, or it is represented there by a very nearly related form which has received from Swallow the name of *Acanthocladia americana*. It is very difficult to judge of this latter form, as neither a figure nor an exact description exists. From the few remarks made by Swallow, it seems to us very doubtful whether *Acanth. americana* can be distinguished from *Acanth. anceps*.

The occurrence of the permian form in the Salt-range is again of much geological importance, and confirms once more the opinion expressed already that the middle and upper divisions of the Productus-limestone must be placed in the permian formation.

Sub-Kingdom: **VERMES.**

Class: ANNELIDA.

Order: CHÆTOPODA.

Sub-Order: TUBICOLA.

Family: ?

Genus: SPIRORBIS, Daudin.

Though the *Annelida* in general present not much interest to the palæontologist, yet they cannot be altogether neglected; they sometimes contribute evidence towards the solution of geological questions.

The genus *Spirorbis* is one of those which have to a certain extent a geological value, as its distribution is very peculiar. Species belonging to the genus are remarkably numerous in palæozoic formations, while they are nearly entirely absent in mesozoic ones, though the genus appears in great numbers again in the recent period. So far the appearance of the genus in great numbers can be considered as of a certain geological value. On the other hand however it must not be forgotten that the determination of worm-like animals from their shells alone is rather precarious; it might very well be the case that the *Spirorbis*-like shells of the palæozoic epoch were inhabited by animals deviating very much from those which now-a-days dwell in such shells. As however the animals of the palæozoic era will never be known to us, we must make the best of it, and must distinguish the shells as far as they are distinguishable.

Thus taking the characters of the shell only, we can describe the genus *Spirorbis* as consisting of small calcareous worm-tubes, spirally coiled, and fixed by the entire under-surface to foreign bodies, only the last whorl becomes sometimes slightly elevated. The spiral is indiscriminately coiled to the right or to the left, and on

the upper side usually provided with a more or less wide umbilicus. The surface of the shell is often more or less richly ornamented, but mostly entirely smooth.

The genus is numerously represented throughout the palæozoic formations, but the distinction of species is not easy, as all the forms not provided with a characteristic ornamentation are more or less alike.

In the Salt-range small specimens of *Spirorbis* occur occasionally fixed to the shells of Brachiopods, Corals, or the like, but they are not very numerous. I can distinguish only one species which shows a close resemblance to a form described by King, from the permian beds of the Humbleton Hill under the name of *Spirorbis helix*, and I think I am not mistaken in identifying the Indian specimens with that species.

1. Spirorbis helix, King, Pl. XCV, figs. 2, 3.

1848. *Spirorbis helix*, King: Catalog., p. 6.
1848. *Spirorbis globosus*, (M'Coy) Howse: T. N. F. C., Vol. I., p. 258.
1850. *Spirorbis helix*, King: Monogr. Brit. Perm. Foss., p. 54, pl. vi, fig. 8.
1861. *Serpula planorbites* (Münst.) Geinitz: Dyas, p. 40 (quotation from King).

These very small shells are of an elevated obtusely conical general shape, with a very small slightly impressed umbilicus on top, and a not very broad base, by which they are fixed to foreign bodies.

The whorls are rounded, somewhat crescent-shaped in their transverse section, almost entirely overlapping each other, so that within the very small point-like umbilicus nothing of the inner volutions can be seen.

The surface of the volutions is smooth and even striæ of growth can be distinguished with difficulty.

The aperture is crescent-shaped, with a well-rounded outer margin or lip, a flat straight lower margin, corresponding to the base, and a concave inner margin, as determined by contact with the preceding whorl.

The substance of the shell is tolerably solid.

The dimensions of these fossils are so very small, that it is barely possible to give measurements. They may best be seen from the drawings on Pl. XCV.

Locality and geological position.—It is not possible for me to give exact numerical indications as to the occurrence of this species in the different divisions of the Productus-limestone, as specimens of it adhere to the most various bodies, and it is impossible to look through all these in search of such minute objects. About half a dozen of them have come to my notice, chiefly adhering to Brachiopods and Corals. They occur in the middle division of the Productus-limestone as well as in the upper division, but have not yet been observed by me in the lower division.

In the middle division I have observed specimens adhering to specimens of *Spirigerella grandis*, W., from Musakheyl and to *Spirigerella derbyi*, W., from Kálabágh. In the upper division the species has been observed by me adhering to specimens of

Streptorhynchus pectiniformis, Dav., and *Derbyia grandis*, W., in the Cephalopoda-bed of Jabi.

Remarks.—This species is very nearly related to *Spirorbis globosus* of the mountain-limestone which has a similarly elevated conical form, but they are distinguishable by the much smaller umbilicus of the Indian fossil.

By Geinitz the present species has been united to *Serpula planorbites*, but I think King's species should be kept separate, as *Serp. planorbites* is a flat widely umbilicated shell, much larger than *Spirorb. helix* and in every respect quite different.

Spirorbis helix is a species of the European permian formation and its occurrence in the Salt-range is thus not without interest.

Genus: SERPULITES, Murchison.

This genus is very easily recognisable on account of its smooth shell, which has a very singular appearance, and in fragments can only with difficulty be distinguished from fish bones or scales.

The shell forms a very long and comparatively thick tube presenting on the whole a rather equal gentle curve, and it may attain the length of a foot and more, so that only more or less extensive fragments of these tubes are commonly found, it being very rare to get a tolerably complete specimen. The shell itself seems to have been somewhat flexible; it is generally compressed without being quite broken. The surface of the shell was apparently shining, either entirely smooth, or provided with wrinkles, tubercles, or the like. The shell-substance is very distinctly composed of several layers, which seem however not to possess very different structures. The shell is always, for the most part, of a dark brown colour, but at the same time there are also many places on which the ashy blue colour of vivianite can be observed. On the whole, in appearance the shell-substance of *Serpulites* very nearly approaches that of the shells of *Lingula*, *Obolus*, and similar *Brachiopoda* which possess a shell composed partly of a horny substance and partly of phosphate of lime, and it seems to me highly probable that the shell of *Serpulites* was of a similar composition. The partial flexibility of this shell makes the presence of a horny substance in it highly probable, as the formation of vivianite in the shell substance proves the presence of phosphorus.

The systematic position of the genus is very doubtful. That this singular shell formed the abode of some worm-like animal cannot be questioned, but beyond this it is very difficult to make any guess. As far as I am aware of, there is no living worm that secretes phosphate of lime in its shell, though there are several that form horny tubes. But all this is of no avail, as among the worms but very little can be inferred as to the nature of the animal from that of the tube which it inhabits. The position of the genus in the class of the *Annelida* must thus be considered as rather arbitrary.

The genus *Serpulites* has chiefly a palæozoic distribution, and apparently its chief development was in the silurian period. In the carboniferous period there were still several species, but in the overlying permian formation the existence of the genus has not as yet been recorded.

In the Salt-range a single species occurs which is restricted to the lower division of the Productus-limestone.

1. SERPULITES INDICUS, Waagen, n. sp.; Pl. XCV, fig. 4.

This is a very large species, and when complete, it must have been of great length. As however only a fragment of it is known, it is impossible for me to indicate to what size the species may have grown.

The fragment that serves for description is entirely compressed, and shows at the same time a flat very equal curve. Its original transverse section must have been circular, but in its present state of preservation the two lateral parts are almost in contact.

The substance of the shell is thin, more or less membranaceous or horny, and must have been soft and flexible, as notwithstanding the great compression it has undergone, it is nowhere distinctly broken, but bent in and out in narrow curves, which can only be explained by supposing that the shell was originally flexible.

The surface of the shell is entirely smooth; even with a powerful lens no striæ of growth can be observed. Owing however to the great compression the shell has undergone, it is covered everywhere with irregular transverse wrinkles.

The shell is shining, of a dark brown colour, changing in places into the ashy blue tint of vivianite; it is composed of many thin lamellæ which easily separate from each other.

The fragment has a length of about 115mm. with a breadth of 20mm. at one end, and 18mm. at the other. There is no aperture at either end of this fragment, so that it must belong to some middle part of the shell. According to these data the entire shell must have attained a length of nearly one metre.

Locality and geological position.—The only fragment of this species that exists in the Salt-range collection was found by Mr. Wynne at Chidru, in the dark sandy limestones, weathering of a rusty brown, composing there the lower division of the Productus-limestone.

Remarks.—It is chiefly to *Serpulites membranaceus*, M'Coy, that the present species may be compared, as the substance of the shell in the two seems rather similar. The Indian species can however be distinguished from the European one by the absence of the thickened parts on both sides of the shell, and by the much larger size. The Indian shell seems indeed to be the largest hitherto made known within the genus.

Of the group of forms without lateral thickenings, to which the present species belongs, none is known above the silurian period. It is therefore of some interest

to see this division of the genus re-appear in strata so comparatively new as the lower division of the Productus-limestone.

Sub-Kingdom: **ECHINODERMATA.**

Class: ECHINOIDEA.

Sub-class: PALÆCHINOIDEA.

Order: PERISCHOECHINIDÆ.

Family: *ARCHÆOCIDARIDÆ.*

Genus: EOCIDARIS, Desor.

The only remains of this genus in the Salt-range collection are some interambulacral plates and a number of spines.

Though these materials are very scanty, they might still possibly serve to elucidate the systematic position of the genus, which has been made somewhat doubtful by Quenstedt.

Quenstedt in his "Petrefactenkunde Deutschlands" admits only the carboniferous species in the genus *Eocidaris*, while he brings the permian forms into closer connection with *Cidaris grandæva*, Gdf., of the Muschelkalk, and with *Cidaris* proper. When however Geinitz in the "Dyas" expressly writes:—"The form of the interambulacral plates is distinctly hexagonal," I cannot see any reason why the permian form should be excluded from the genus. I even think that Quenstedt himself figures quite distinctly hexagonal interambulacral plates even of *Cidaris grandæva* (Petrefk. Deutschl., Vol. III, Pl. LXVII, fig. 3), and thus perhaps this species also had better be transferred to *Eocidaris*.

The forms that have been mentioned are all very small. *Eocidaris rossica*, Buch, which occurs plentifully in the upper carboniferous limestone of Mjatshkowa is much larger. The plates of this species seem however to be nearly always much deteriorated, so that even the crenulated margin round the tubercle is mostly obliterated, and the exact outline and nature of the margins of the plates can rarely be well observed.

This latter point can be well seen in the specimens from the Salt-range, which however belong to a different species. The margins of the plates are vertically cut only on two sides, while the remaining margins are obliquely beveled, thus indicating that the plates were only partially joined together firmly, while in other directions they were probably partly overlapping, and moveable to a certain extent. The shape of the plates cannot be very exactly determined, as one half of them are always broken. The sculpturing however exactly corresponds to that generally occurring in *Eocidaris*.

Now though these plates are gigantic in comparison with their congeners in the permian formation of Europe, yet their position in the genus cannot well be doubted. In this case however the genus *Eocidaris* cannot possibly be placed otherwise than in the family *Archæocidaridæ*, as in this family only do moveable interambulacral plates occur.

In the Salt-range, fragments of the test as well as spines of this genus are not rare, but they are always in such a disunited state, that it is often difficult to decide what may belong to one and the same individual or species. The spines chiefly show very varying forms. Sometimes they are rather large, thickly fusiform and bear very coarse regularly arranged granulations, sometimes they are much smaller and provided with a very fine irregular granulation. But these different shapes are always found together, and I do not think that different species are indicated by them. Thus there would be only one species of the genus in the Salt-range, and this has already long since received the name of *Cidaris forbesiana* from Mons. de Koninck.

1. Eocidaris forbesiana, Koninck., sp. Pl. XCV, fig. 5-16.

1863. *Cidaris forbesiana*, Koninck: Quart. Journ. Geol. Soc. Lond., Vol. XIX, p. 4, pl. IV, figs. 1-2.
1863. *Cidaris forbesiana*, Koninck: Fossiles paléozoiques de l' Inde, p. 22, pl. III, figs. 1-2.

The species was founded by Mons. de Koninck on a number of isolated spines brought from India by Dr. Fleming.

The spines are not rare in the Salt-range; isolated plates of the body are however much rarer. Nevertheless, wherever I found plates the spines were not far off, and thus it becomes highly probable that spines as well as plates belong to one and the same species.

To begin with the plates, they are large, nearly quite flat, showing only a slight curvature in either direction. Their general shape is very irregular, but the greater number of them have a more or less octagonal outline, while only rarely a plate is found with a hexagonal or pentagonal contour. In the octagonal plates, the upper and lower margins are mostly the longest, and next in length come the margins to the right and left, while the corners of the somewhat irregular quadrangle thus formed are irregularly cut off, whereby the remaining four sides of the octagon are supplied. In the hexagonal or pentagonal plates one of the lateral margins is longest, and joined to the upper and lower margins under approximately right angles; the other margins are formed either by a very short lateral margin and correspondingly long edges cutting off the angles, or these oblique edges may extend so far that the lateral margin entirely disappears, and then a pentagonal plate is produced.

Of all these margins mostly only those directed towards the upper (?) and lateral sides are cut vertically, while the others are obliquely beveled, so that the outer contour of the plate remains untouched. Thus probably the plates rested partly on each other like scales.

The surface of the plates is very characteristically ornamented. Each plate bears in the middle a very large primary tubercle, supported by a high elevated neck, furnished on its upper edge with a deeply crenulated collar. The tubercle itself is nearly always broken away, but the crenulated collar is so much the better exposed. In the depth of the cavity which had been occupied by the tubercle, a rather large foramen is observable, pointing to the perforated nature of the tubercles. Round this very thick and large central primary tubercle a rather large smooth scrobicule of a somewhat transversely oval general outline is developed. This is again surrounded by a very narrow scrobicular margin, which is however nowhere interrupted and bears a single row of not numerous, rather large, distant secondary tubercles.

The radiols have been described already by Mons. de Koninck, and are that part of the animal upon which the species has been founded. They are however apparently very variable in shape and ornamentation, and I must describe the different shapes separately.

The shape originally described by Mons. de Koninck, and which must be considered as the typical one, occurring at the same time most frequently, is thickly fusiform, not quite distinctly pointed, but mostly with a somewhat blunt or more or less truncated extremity. The spines are generally rather flattened on one side and thus acquire a more or less triangular transverse section. Towards the articulating extremity the spines are distinctly tapering, whereby a tolerably long distinct but never very thin neck is produced. The head is thick, provided with a strongly prominent ring. The articulating facet is comparatively small, rather deeply sunk in, perforated in the middle, and surrounded by a prominent strongly crenulated margin.

Another shape that is to be found often on the same slab as the preceding one, is long and bacillary. These spines are thin, not more than 2 to 3 millimetres in thickness, and comparatively very long. They are but very little or not at all tapering towards the head, and thus the neck is only distinguishable by the smoothness of its surface. The stalk is also of a somewhat triangular section, a little flattened on one side, and is provided with a fine longitudinal ribbing, on which fine granules are placed. The head is not very thick, is provided with a but very slightly prominent ring, and bears at its extremity a small articulating facet surrounded by a crenulated circle.

The third shape comprises spines of a much smaller size, which were probably attached to secondary tubercles. They are fusiform, tapering at both ends and not very thick. The surface of these spines is almost smooth, only provided with a very slight irregular granulation exhibiting somewhat the appearance of chagrin leather. The section is circular or somewhat elliptical but not triangular. At one end of the spine the surface becomes entirely smooth whereby a sort of neck is produced. Any head is however entirely absent, as well as the ring which would surround it. The spine is simply terminated at one end by a small hollowed-out

articulating facet. It cannot be exactly determined whether this facet was granulated or not.

The materials of this species at hand are not sufficiently well preserved to give any measurements. The dimensions of the single parts can best be seen from the drawings on Pl. XCV.

Locality and geological position.—The present species is entirely restricted to the solid limestones, impregnated with silica, composing the middle region of the middle division of the Productus-limestone. Thus the spines as well as the interambulacral plates are nearly always silicified, and this circumstance makes it so extremely difficult to obtain tolerably well preserved specimens. The specimens are always exposed on weathered surfaces of huge limestone blocks, and generally there is no means of separating them from the matrix. Thus, though the species is not very rare, only very few specimens have been brought away by Mr. Wynne or by myself. Specimens of spines as well as of interambulacral plates have been found at Katta, at Golawáli, at Chidru and in the Bazárwán.

Remarks.—It must be very much regretted that no better materials are available of this species, as beyond doubt it is one of the most interesting in the Salt-range. The small fragments available point already to very peculiar characters in the species. If we pass in review all the forms of *Eocidaris* described up to the present, we find that there is only one which on the whole rather nearly approaches the present species, and that is *Eocidaris rossica*, Buch. This species also has interambulacral plates, of a very irregular shape, and apparently very loosely joined together. It is true that Trautschold described this species as an *Archæocidaris;* but its characters, as pointed out by Quenstedt, are those of *Eocidaris* and not of *Archæocidaris*. The absence of a crenulation on the collar round the tubercles must be attributed only to the mode of preservation of the specimens, as Mr. Trautschold himself remarks that on the radials at least, the articulating facet when perfectly well preserved bears such a crenulation that can hardly be absent on the tubercles under like conditions. From our *Eocidaris forbesiana* the Russian species can very easily be distinguished by the much smaller size of the interambulacral plates and their very different outline; also, the radials are much less massive.

Of other forms, chiefly *Lepidocidaris* must be compared. The general characters of the interambulacral plates are very similar in both fossils, but in *Lepidocidaris* the plates are on an average smaller, the tubercles almost minute and devoid of a crenulated collar, and the spines are entirely different.

All the species of true *Archæocidaris* can be easily distinguished from the form here under consideration, by different sculpturing of the interambulacral plates, characteristic of the genus.

Class: CRINOIDEA.

Order: EUCRINOIDEA.

Sub-order: TESSELATA.

Family: *CYATHOCRINIDÆ.*

Genus: CYATHOCRINUS, Mill.

The distinction of this genus from *Poteriocrinus* is very difficult if one has to deal with specimens in which the upper vaulted covering of the body and the arms are not preserved, and the determination of such specimens must always remain somewhat arbitrary.

In general, at least as regards carboniferous and permian forms, one is wont to consider as belonging to the genus *Cyathocrinus* those forms only in which one nearly symmetrical *interradiale anale* is inserted in the cycle of the first radials, so that, though the body is in fact not symmetrical, yet a certain symmetry is attained. On the contrary, the forms generally placed in the genus *Poteriocrinus*, are those in which there occur two or three anal interradials, of which the first is inserted obliquely between one of the parabasalia and one of the radialia, while only the second is distinctly a member of the cycle of the radials.

Both these genera are richly represented in the carboniferous formation of Europe, and extend with a few species up into permian beds. The first of them contains the wide-spread permian species *Cyathocrinus ramosus*, Schloth., while the second has up to the present furnished a representative, *Poteriocrinus quenstedti*, Golovk. only in the Russian permian formation.

In the Salt-range several species occur; they all however seem to correspond more closely with *Cyathocrinus* than with *Poteriocrinus*, though no sufficiently well preserved specimens have been found to allow of a perfectly safe determination.

Two groups of forms can be distinguished among the Salt-range specimens; one group with a small body and a very small lancet-shaped anal interradial piece, and another group with a large body and a squarish anal interradial piece. For both these groups representatives can be found among the species already described from other countries.

The first group has its representative in the well-known *Cyathocrinus ramosus*, Schloth., of the permian formation of Europe, though the specimens from the Salt-range are at least twice as large as those from Europe. The second group is typified by the gigantic species *Cyathocrinus koninckí* from upper-carboniferous beds of Australia. Each of these groups is represented in the Salt-range by two species, all of which occur in the middle division of the Productus-limestone.

We have thus within the genus *Cyathocrinus* to distinguish in the Salt-range the following species:—

I.—Group of Cyathocrinus koninckı, Clarke.
1.—*Cyathocrinus goliathus*, Waagen, n. sp.
2.— „ *virgalensis*, Waagen, n. sp.
II.—Group of Cyathocrinus ramosus, Schloth.
3.—*Cyathocrinus indicus*, Waagen, n. sp.
4.— „ *kattaensis*, Waagen, n. sp.

As will be seen from the names here introduced, none of these four species can be identified with any hitherto described form.

I.—Group of *CYATHOCRINUS KONINCKI*, Clarke.

1. Cyathocrinus goliathus, Waagen, n. sp., Pl. XCVI, figs. 6—12.

The body of this very large species is known to me only from isolated plates, but as nearly every one of the cycles composing the body is represented, the species can be fairly reconstructed.

The body seems to have been somewhat inflated, cup- or balloon-shaped, and was composed of three cycles of plates, *viz.*, the *infrabasalia*, the *parabasalia*, and the *radialia*. Of the *interradialia analia* only one is known to me.

Of the *infrabasalia* none is preserved in the Salt-range collection, but from the impressions left on the *parabasalia*, it appears that this first cycle was composed of five plates, the upper margins of which formed a pentagon with nearly straight sides; but already in this first cycle the *interradius analis* seems to have been marked by a certain irregularity in the plates, as the lower margin of the lateral *parabasalia* is developed unsymmetrically. The *parabasalia* are of a more or less regularly pentagonal outline, the height being equal to the breadth, while the *parabasale* which was in contact with the *interradiale anale*, was probably hexagonal, but no specimen of this plate is preserved in the Salt-range collection. The *parabasalia* are all well vaulted, but otherwise they are smooth, without any sculpturing. Of the *radialia*, probably only three were of a quite regular shape, while the two adjoining the *interradiale anale* were probably more or less irregular. As it is, only a few radial pieces of a quite regular shape have been found. They are depressed, pentagonal, much broader than high, the entire upper breadth being occupied by a large articulating facet. At its upper extremity the plate extends internally in a somewhat swallow-tailed process. The outer surface of these radial pieces is strongly vaulted and smooth. The greatest breadth of these *radialia* is at their lower extremity, so that the whole body must have been contracted at its upper margin, as we see to be the case in *Cyathocr. koninckı*.

On Plate XCVI, fig. 9, I have figured a plate which I take to be an *interradiale anale*. The piece is irregularly four-sided and of an unequal thickness, being thicker to the right than to the left—a condition which might however have been produced by abrasion before the piece had been imbedded, and the strata in which these crinoids are found do show signs of strong wave-action at the time of their deposition.

The piece is vaulted outside and smooth. The irregularity of the general outline of this piece suggests the probable existence of some other *interradiale anale*.

The stems with much probability belonging to this species are thick, round, composed of numerous low entrochi (joints), four to five times as broad as they are high. They are often thickly and irregularly set with cirrhi, but they just as often quite smooth. The articulating facets of the joints show a large round median canal, surrounded by a narrow belt of fine granulation, after which a rather broad smooth zone follows, while along the margin a rather coarse radial notching occurs.

It is not possible to give any measurements, as only fragments of the species are known, and the dimensions of these may best be seen from the drawings. On the whole, it is very probable that the form of the body was to a certain extent balloon-shaped, as is the case in *Cyathocr. koninckí*, the greatest breadth not being situated at the upper margin, but about in the middle height of the body.

Locality and geological position.—This is one of the commonest species of the Salt-range, as fragments of it fill all the beds of crinoidal limestone in the middle division of the Productus-limestone, which attain locally a thickness of more than a hundred feet. But though the fragments are thus heaped together by millions, yet I never found a complete body. Mostly the fragments are strongly rolled and broken, indicating a strong wave-action during the formation of these crinoid-limestones; only very rarely are well preserved single plates of the body found, when the limestones become more marly in certain beds. Such is the case at Virgal, where marly beds of a red colour are intercalated between the compact limestones, and in these marls some better specimens can be obtained. Other such localities were west of Khura, at the base of the upper Productus-limestone, and at the village of Khura itself, in the top beds of the middle division, also in the Chittawán and at Bilot.

Remarks.—The species which seems to be most nearly related to the one under description is *Cyathocrinus koninckí*, Clarke, which has been described by Mons. de Koninck from carboniferous beds of Osterley on the Hunters River of Australia. The diagram given of this species by Mons. de Koninck is however not in accordance with the other figures, as in this diagram the *infrabasalia* are triangular in shape, and correspond by one of their sides with the basal side of the *parabasalia*, while in the other figures the *infrabasalia* are quadrangular and alternate with the *parabasalia*. I think the diagram must be erroneous, and the other figures correct. If we now take these representations for comparison with the Indian specimens, we find that there exists a strong typical resemblance between the two, and it appears highly probable that the body of *Cyath. goliathus*, W., had the same general globular shape as *Cyathocr. koninckí*. But other well-marked differences exist. The Indian species is much smaller, and its parabasalia are without radiating ridges. Thus it is evident that they form two distinct species, but it is interesting to observe here a form so nearly related to an Australian species, as such an occurrence is rare in the Salt-range fossils.

Of other species none is known to me which could be more particularly compared to *Cyathocr. goliathus*, W.

2. CYATHOCRINUS VIRGALENSIS, Waagen, n. sp., Pl. XCVI, figs. 13-15.

Another but a much smaller form seems to be indicated by some *parabasalia* and several fragments of stems collected by me at Virgal, but the materials are very scanty.

The *parabasalia* are irregularly five-sided, or somewhat six-sided, as the basal faces of the plates are made up of two rather indistinct facets. They are flatly vaulted in every direction and quite smooth. Their chief character however consists in the circumstance that they are somewhat broader than high.

Of the remaining plates of the body, nothing is known to me.

To the same species belong with great probability some fragments of stems that are not very thick and decidedly beaded, each joint being somewhat swollen in the middle. The joints are irregular in thickness, but generally they are comparatively higher (thicker) than in *Cyathocr. goliathus*. The articulating facet is pierced in the middle by a large canal and bears a rather coarse notching along its circumference.

Locality and geological position.—The species seems on the whole not rare, though it is certainly rarer than the preceding one. It has however no doubt furnished a large contingent of the fragments with which the crinoid beds of the middle Productus-limestone are filled. The parabasal plates, described above, were found by myself in the same red marl-beds at Virgal which furnished the pieces of *Cyathocr. goliathus*. Fragments of stems probably belonging to the species were collected by me at Virgal in the Coral and Crinoid-beds, and in the Chittawán (middle Productus-limestone).

Remarks.—It might appear somewhat doubtful whether the present species should be separated under a distinct name from the preceding one, as in general appearance the *parabasalia*, the only parts that are known to me, very much resemble the same parts of *Cyathocr. goliathus*, and are chiefly distinct only by their smaller size, so that it appears very possible that they only represent the young state of the larger species. I held this opinion myself for some time, but after careful consideration I came to distinguish the forms, as very probably indicating the existence of two different species. The smaller plates presented a very constant size, and always deviated from the larger ones by the circumstance that the transverse diameter was greater than the height, while in the larger plates both dimensions are always exactly identical, also the shape of the smaller specimens was always more strongly unsymmetrical than was observed in the majority of specimens of *Cyathocrinus goliathus*.

Thus it appeared to me highly probable that the smaller plates belonged to a species different from *Cyathocr. goliathus*, and accordingly I introduced a new name for this species.

From *Cyathocr. koninckı*, Clarke, the present species is easily distinguishable by its much smaller size, and by the smooth parabasal plates. It is however probable that also *Cyathocr. virgalensis* bore a certain affinity to that Australian species.

II.—Group of *CYATHOCRINUS RAMOSUS*, Schloth.

3. Cyathocrinus indicus, Waagen, n. sp., Pl. XCVI, fig. 1.

The materials of this species, though not very complete, are yet sufficient to give a tolerably full description of it, the complete body, without the arms, and the stem being known to me.

The species is of rather small dimensions, although nearly twice as large as the true *Cyathocrinus ramosus*.

The body is of an elevated conical outline with entirely straight or but very little vaulted sides. It is composed of three cycles of plates, *viz.*, the *infrabasalia*, the *parabasalia* and the *radialia*. The *infrabasalia* are five in number, and of an approximately quadrangular outline. In general configuration however they appear geniculated, the truly basal part being turned inside and forming a little triangle, all five triangles together composing a round, articulating, facet for the insertion of the stem. That part however which belongs to the outer wall of the body is turned up, and shows on the whole a pentagonal outline. It is somewhat vaulted transversely, according to the curvature of the outline of the articulating facet below. This pentagonal upright part of the infrabasal plates is about as high as it is broad. The angle by which it is marked off from the basal part is obtuse and rather sharply marked.

The *parabasalia* are also five in number, alternating with the *infrabasalia*. They are much larger than the latter and a little vaulted in every direction. Four of them are pentagonal, the lower side often forming a broken line; the pentagons are somewhat higher than broad. In the fifth plate the upper corner of the pentagon is cut off, and thus this plate becomes hexagonal, though the sixth side is very short. To this short sixth side the very small *interradiale anale* is joined.

The five *radialia* alternate again with the *parabasalia*. They are all of an about equal shape, short and broad, and on the whole smaller, but more massive than the latter. Their general outline is short, reversed, pentagonal, the longest side being above and nearly for its entire length occupied by an articulating facet. The surface of the *radialia* is vaulted longitudinally as well as transversely. Two of the *radialia* are very slightly irregular in their outline, being a little shortened on one side, to give room for the very small *interradiale anale* which is inserted between them.

The single *interradiale anale* in hand is very narrow, lancet-shaped, and of a somewhat hexagonal outline. It projects rather far above the *radialia* by which it is hemmed in on both sides. Its outer surface however is sunk in between the radialia, and marks a rather deep impression on the body. On its lower side it is joined to that one of the *parabasalia* which is hexagonal by its upper corner being cut off in a straight line.

The stem of this species is very distinctly beaded. Each joint is inflated in the middle and bears on its upper and lower sides somewhat raised articulating facets. As these facets have a smaller diameter than the body of the joints, it comes that

each joint bears at its lower and upper end a smooth ring, caused by the raised position of the articulating facets. The beads of the stem, which are made up of the swollen bodies of the joints are thus separated from each other, by smooth deepened spaces. The articulating facets themselves bear a ring of short notches all round the periphery. The median part is smooth and pierced in the middle by a not very large round nutrition-canal.

The dimensions of the body are as follows :—

Entire height of the body	11·5	mm.
Greatest diameter at the upper end	14	„
Diameter of the articulating facet at the lower extremity	5	„
Greatest height of the *infrabasalia*	3	„
„ breadth „ „	3·5	„
„ height „ *parabasalia*	7	„
„ breadth „ „	6	„
„ height „ *radialia*	4·5	„
„ breadth „ „	9	„
Height of the *interradiale anale*	4	„
Breadth „ „ „	1·5	„
Angle formed by the lateral walls of the body	60°	

Locality and geological position.—Up to the present there has been found only one entire body of this species. This was collected by myself at Nursingpohár in the black sandy-limestones, forming there the base of the middle division of the Productus-limestone. Fragments of the stem were found in the immediate vicinity of the body, so that it appears highly probable that both belonged to one and the same species. Very similar stem fragments, which with great probability can be assigned to this species, were collected by me also at Amb in the lower division of the Productus-limestone, in the very lowest fossiliferous beds above the lavender-clays.

Remarks.—The present species seems to be very nearly related to *Cyathocrinus ramosus*, Schloth, the widely spread permian species of Europe. It is very much to be regretted that the body of *Cyathocrinus ramosus* is so very rare that up to the present the exact characters of the species have remained somewhat doubtful. The specimen described by King was damaged at its base, and thus the shape of the *infrabasalia* could not be made out; the *parabasalia* and *radialia* were well preserved and it could be stated, that in the anal interradius three *interradialia analia* were present; the general shape of this specimen is flatly conical. On the specimen described by Geinitz in his memoir on the Nebrasca fossils, the *infrabasalia* are on the contrary well preserved but small. Of *interradialia analia* there is only one present, and the whole shape of the body is more elevated conical. From this it becomes highly probable, that in the European permian beds two different species of *Cyathocrinus* exist, of which the German specimen would represent the true *Cyathocrinus ramosus*, Schloth, while the English specimen would probably have to receive a new name. As it is, the Indian specimens show a more close affinity to the typical German form than to the English one.

They are nevertheless easily distinguishable from the German typical *Cyathocrinus ramosus*. Already the much larger size of the Indian species is an acceptable

distinguishing character. To this can be added the different shape of the *interradiale anale*, which is much broader and shorter in *Cyathocr. ramosus* than in the Indian species. Otherwise the two forms are very similar and can perhaps be considered as vicarious species of an approximately equal geological age.

4. CYATHOCRINUS KATTAENSIS, Waagen, n. sp., Pl. XCVI, fig. 2.

Also of this species there exists only a single body, which was collected by myself. But though the material thus seems to be rather scanty, yet this body deviates so considerably from the one described before that I cannot unite both under one name, but have to consider the present one as belonging to a different species.

The body is small and flatly conical or cup-shaped. The sides are tolerably flat, the single plates however being somewhat vaulted. The whole body is composed of three cycles of plates, the *infrabasalia*, the *parabasalia* and the *radialia*. Of each of them five are present.

The *infrabasalia* have on the whole a geniculated shape, as one part of them is bent inside to form the articulating facet, at the insertion of the stem, while the remaining part is bent up and forms part of the lateral walls of the body. This bent-up part, which alone is visible in a lateral view of the body, is very narrow and of an approximately quadrangular outline. It is flat, not inflated, and is bent only in the general curve of the body. The upper margins of two adjacent infrabasal plates fall into one line, the five plates thus forming together a regular pentagon.

The *parabasalia* are all regularly pentagonal, with the exception of one. In each single plate the basal side is longest, and the two lateral sides shortest. It thus happens that the pentagons become considerably broader than long. While this is the shape of four of the parabasalia, the fifth is hexagonal, with its upper corner cut off and replaced by a short sixth-side, for the reception of the base of the very small *interradiale anale*. All the *parabasalia* are slightly inflated and present a surface vaulted in every direction.

The *radialia* are all tolerably equal in size and shape, only two of them are slightly shortened laterally to make room for the small *interradiale anale* mentioned above. Their shape is very strongly pentagonal transversely, the longest side being above, bearing an articulating facet nearly as long as the whole plate. The shortest sides of the pentagon are the two lateral ones, while the two remaining are of a medium size. These radial pieces are rather thickly swollen in the middle of the upper margin while they are somewhat attenuated towards the lateral extremities, whereby little grooves are formed where two of the radialia meet.

The single *interradiale anale* has been lost in the specimen that serves for description. From the place it once occupied, it can however be judged that it was very small and narrow, probably in shape similar to that of the preceding species.

The stem of this species is well known, and there can be no mistake about it, as portions of it were found by me in connection with the body, though in detaching the specimen the stem was broken to pieces. The stem is remarkably thin, and

composed of rather high smooth cylindrical joints, which are as high as they are broad. The articulating facets are smooth in the middle, with a row of small notches all round, and pierced in the centre by a very small canal. On the whole the stem is very similar to that of *Encrinus*.

The measurements of the body here described are as follow :—

Entire height of the body	10 mm.
Greatest diameter at the upper end	18 „
Diameter of the articulating facet at the lower extremity	4 „
Greatest height of the *infrabasalia*	2 „
„ breadth „ „	4·5 „
„ height of the *parabasalia*	6 „
„ breadth „ „	7·5 „
„ height of the *radialia*	5 „
„ breadth	11·5 „
Breadth of the *interradiale anale*	1 „
Angle made by the lateral walls of the body	82°

Locality and geological position.—The only specimen of this species known to me was collected by myself at Katta in yellow limestones forming the base of the middle division of the Productus-limestone (bed No. 12 of my note book). The stem was still attached to the body, but the arms were wanting.

Remarks.—The species here under consideration is very nearly related to the preceding one, but is easily distinguishable by the different shape exhibited by the whole body, and the different development of each of the three cycles of plates composing the body. It needs only a comparison of the measurements given of the two species to become aware of these differences. The exceptional thinness of the stem is also a character worthy of notice. All these differences are not very much it is true, but they seemed to me quite too considerable to admit of uniting under one specific name the two forms here described.

To the true *Cyathocr. ramosus*, Schloth, the present species is perhaps still more nearly related than the preceding one, but also in this case the size of the Indian species is about twice that of the European permian form, and also the shape of the single plates is somewhat different. The genus *Phialocrinus* of Trautschold might also be compared.

Family :—*POTERIOCRINIDÆ.*

Genus ? HYDRIOCRINUS, Trautschold.

It is in an absolutely provisional way that I quote here this genus of Trautschold's. There is nothing from which I could with any certainty deduce the presence of the genus in the Salt-range. The sole reason which induces me to allude to it is the occurrence in the Salt-range of five-sided stem fragments which might possibly, as *Hydriocrinus* is said to have a pentagonal stem, have pertained to an animal belonging to the genus. It is quite true that *Hydriocrinus* is not the only genus in which a pentagonal stem occurs, but it is a genus of the upper carboniferous limestone of Russia, and the same genus might perhaps also have extended

into the Productus-limestone, as the latter is not so very far different in age from the former.

Phialocrinus also, a genus which occurs together with *Hydriocrinus*, is said to have a pentagonal stem; but as no figure of the stem has been given by Trautschold, a comparison is impossible.

1. ? Hydriocrinus, sp. indet; Pl. XCVI, figs. 3, 4, 5.

All that has been found of this species up to the present in the Salt-range are some joints of the stem, which show a decidedly pentagonal outline.

These joints are generally very flat, their height being not more than one-fourth of the diameter. The sides of the pentagon are mostly impressed, so that the corners project considerably; sometimes however the sides are straight. Vertically the sides of the joints are always rounded, so that the stems must have shown a transversely ridged appearance, as in *Pentacrinus cingulatus*. Some of the joints bear articulating facets on every one of the five sides, for the reception of lateral cirrhi. The articulating facets, by which each joint is terminated above and below, are hollowed out, and bear in the middle a smooth pentagonal face which is again pierced in its centre by a rather large round canal. Along the margins of the facets rows of notches of unequal size are observable, the longest being in the middle, while towards the corners they become very small.

It seems unnecessary to give any measurements of these small objects, as their dimensions can be sufficiently seen from the figures given on Plate XCVI.

Locality and geological position.—Fragments of stems of pentagonal outline are rather rare in the Salt-range, and are restricted apparently to the upper division of the Productus-limestone. Some specimens were found by myself in the hills east of Katwáhi in the lower beds of the upper division, and another specimen I detected in the light-coloured sandstones forming the topmost beds of the same division at Virgal.

Remarks.—Though these pentagonal joints of crinoid stems seem to be very insignificant, yet it is remarkable that very similar things have also been found elsewhere in beds of a similar geological horizon. There has been described by Golovkinsky something very similar from permian beds of the Kama-Wolgaie basin of Russia under the name of *Pentacrinus*, sp. Now it seems to me that neither the permian specimen nor the specimens from the Salt-range can rightly be placed in the genus *Pentacrinus*, as none of them has the characteristic leaflets of notches with which the articulating facets of *Pentacrinus* are provided, the notches form simple rows along the margins of the pentagonal articulating facets. From this it appears that these fossils can with some probability be placed in some palæozoic genus of crinoids but not in *Pentacrinus*.

Genus: POTERIOCRINUS, Mill.

The indication of the existence of this genus cannot be founded on any firmer ground than has been offered for the preceding genus. There are merely some frag-

ments of stems in the collection that I attribute in a somewhat arbitrary manner to the genus *Poteriocrinus*. As due excuse for this proceeding it might perhaps suffice that I consider the beds in which these fossils occur as of probably permian age, and that in the permian formation besides the genus *Cyathocrinus* only the genus *Poteriocrinus* has been found up to the present. The stems now under consideration belong to none of the species of *Cyathocrinus* described above, and there may perhaps be indicated by them the existence of species of *Poteriocrinus*. This is all I can say in favour of my determination.

There are two different shapes of stems, which might perhaps belong to the present genus, but none of which can receive a specific designation. By figuring and describing them I may perhaps draw to this point the attention of some later visitor to the Salt-range, to search for the bodies of these forms.

1. ? Poteriocrinus sp., ind., Pl. XCVI, figs. 16, 17, 18.

The stem-fragments here under consideration are rather thick, and belong to a large species. They are composed of low joints which are either all of an equal thickness or alternately thicker and thinner. Their height is very often not more than a tenth of their diameter, while in other specimens it increases to a sixth of the same. These thicker joints mostly bear laterally small articulating facets for the insertion of cirrhi. The lateral walls of the joints are always quite smooth, never swollen or vaulted. The articulating facets, limiting the joints above and below, are pierced in the middle by a not very large round canal, and their whole surface is provided with a fine radial striation, which begins at the centre and extends to the margin. It is composed of fine elevated ridges, which augment towards the margin either by being dichotomous or by the insertion of new ridges between the old ones.

A piece of the root figured in Plate XCVI, figure 18, shows very irregular joints.

Locality and geological position.—Fragments of stems of this description are not very numerous in the Salt-range, but occur off and on in the middle as well as in the upper division of Productus-limestone. The species has been found somewhat more numerously by Mr. Wynne at Morah in the middle division, and by myself in the *Cephalopoda*-bed of the upper division at Jabi.

Remarks.—Stem-fragments of a similar description to those described here are found throughout the palæozoic formations, and there would be no apparent use in entering here upon comparisons. All that is needed is to register the occurrence of such stems in the Salt-range.

2. ? Poteriocrinus, sp. ind., Pl. XCVI, figs. 19, 20.

The fragments of stems that I consider as having belonged to a species different from the preceding are much less considerable in thickness, and indicate an altogether smaller species.

The stems are of a moderate thickness, with rather high joints, and perfectly smooth and cylindrical, apparently without lateral cirrhi. The height of the joints is about one-third to one-half of their diameter, and in this respect and in their smooth surface they resemble exceedingly the entrochi of *Encrinus liliformis*. They differ however considerably from that species by the characters of the articulating facets. These are smooth for the greater extent, and pierced in the middle by a large pentagonal canal. Round the margin there are short coarse notches as in *Encrinus*.

Locality and geological position.—Of all the crinoid stems occurring in the Salt-range, the ones here under consideration are the rarest. They are restricted to the middle Productus-limestone, and have been found in single fragments by myself and Mr. Wynne at Katta, at Khura and at Bilot.

Remarks.—The stem-fragments here under consideration are distinct from all the others, occurring in the Salt-range by their pentagonal canal. Joints of a similar description occur however in several palæozoic formations and their occurrence in the Salt-range is of no geological value.

Family: *HETEROCRINIDÆ.*

Genus: PHILOCRINUS, Koninck.

This genus was created by Mons. de Koninck for a fossil coming from the Salt-range; but though this is the case I can give but little new information on it, as tolerably well preserved specimens are very rare, and there is none in the collection to show all the characters necessary for the proper definition of the genus.

The genus was originally characterised by Koninck in the following manner:—"The characters consist chiefly in the existence of five basal-plates of a quadrangular form, alternating with five rows of radial plates, to the number of two for each ray. The second plate is cuneate, and supports two series of brachial plates, also two in number; each of these, finally, giving support to two series composed of a great number of brachial plates, thus producing about twenty free arms. All the other plates are soldered one to the other, and form the calyx." The genus is then compared to *Encrinus* and *Millericrinus*, and is said to differ from them in having only two radial pieces whereas they have three.

This description was drawn up from a specimen that is now lost, and in the Salt-range collection there is not one so complete. Nevertheless on one of the specimens at my disposal something can be observed that was not visible on Mons. de Koninck's specimen, and this is a small *interradiale anale*. Thus the diagnosis of the genus can now be drawn up somewhat more completely than heretofore.

The diagnosis may be framed in the following manner, according to the nomenclature introduced in Zittel's Hand-book. It remains doubtful whether there were *infrabasalia* or not; on the whole however it seems rather probable that small infrabasalia were present. The *parabasalia* are comparatively large, much higher

than broad, of an elongated pentagonal shape. They are all five absolutely identical in outline, and the anal interradius cannot be distinguished in this cycle by any deviating shape of one of the plates. The *radialia* alternate with the *parabasalia*, and three of them are of a broadly pentagonal outline. The remaining two are hexagonal, as a small *interradiale anale* is partly sunk in between them. The upper margin of the *radialia* is entirely taken up by a large articulating facet to which the first *brachiale* is joined. The small *interradiale anale* is of an irregular pentagonal shape. It is only partly inserted between two of the *radialia*, not reaching down to one of the *parabasalia* but stopping half-way. One of the sides is joined laterally to one of the *brachialia*, whilst the last remaining side seems to have been in connection with a second *interradiale anale*, which was inserted between the *brachiale* on the other side and the first *interradiale*.

The first *brachialia* are axillary, and in shape similar to the *radialia*, only reversed, the longest side being below, articulating with the upper facet of the radialia. All five have about the same shape, only the two adjoining the *interradialia analia* are somewhat narrower.

After the first brachialia follow two more, of which the second is again axillary, so that altogether twenty arms are formed.

The arms do not divide again. They are made up of alternating pieces.

These are the characters of the genus. It has till now been supposed that the genus had no *interradiale anale;* but a specimen from Bilot shows most clearly the existence of such.

The genus was for a time considered to be identical with *Erisocrinus*, Meek and Worthen, but this opinion was soon given up again by this author himself. Now, after the existence of an *interradiale anale* has been demonstrated in *Philocrinus* the affinity is still far more remote. The systematic position of the genus *Philocrinus* cannot however be altered by this discovery. The *interradiale anale* is not in connection with one of the *basalia*, but is in its position very similar to the small *interradiale anale* of *Graphiocrinus*, Kon., and this position, I think, is essential for the retention of the genus in the *Heterocrinidæ* of Zittel. From *Graphiocrinus* the genus is easily distinguishable by an entirely different shape of the body and the existence of twenty instead of ten arms.

There exists only one species of the genus in the Salt-range.

1. Philocrinus cometa, Koninck., Pl. XCV, figs. 17—20.

1863. *Philocrinus cometa*, De Koninck: Quart. Journ. Geol Soc. Lond., Vol. XIX, p. 4, Pl. II, fig. 5.
1863. *Philocrinus cometa*, De Koninck: Fossiles paléozoiques de l'Inde, p. 21, Pl. II, fig. 5.

The body is of moderate size and of a thick obtusely conical outline. There has no specimen been found up to the present with the base of the body perfectly preserved, and therefore it is not known whether there existed infrabasal plates or not. The *parabasalia*, the *radialia*, and the different brachial plates are of the

description indicated in the characteristic of the genus. All these plates are perfectly smooth and not vaulted, except according to the general curvature of the surface of the body. The arms are long, simple, and for their whole extent of about equal thickness. They are made up of rather thick alternating joints, and there have not been observed up to the present any traces of pinnulæ. The arms adjoining the anal interradius seem not to differ from the remainder.

The stem of the species is not known with certainty, but very probably the fragments figured by me, Pl. XCV, fig. 20 belong to it. They are made up of rather thin joints in which the height is about one-third of the diameter. Their general form is round with slightly vaulted sides, so that the whole stem appears very slightly beaded. Cirrhi have not been observed by me. The articulating facets are smooth for the greater extent, and are pierced in the middle by a rather large canal. All round the periphery the facet bears a tolerably fine notching.

The measurements are approximately the following:—

Entire height of the body, up to the last splitting of the arms	28 mm.
Height of the body up to the first brachiale	16 „
Greatest transverse diameter of the body	25 „
„ height of the *parabasalia?*	9 „
„ breadth of the „	8 „
„ height of the *radialia*	5 „
„ breadth of the „	9 „
„ height of the first *brachiale*	6 „
„ breadth „ „ „	11 „
Height of the *interradiale anale*	4 „
Breadth of the „ „	5 „
Angle made by the lateral walls of the body	35° to 55°
Length of the arms, about	60 „

Locality and geological position.—Well determinable bodies of this species are very rare. One was collected by Mr. Wynne at Bilot. Where the specimen described by Mons. de Koninck came from is not known. As far as my experience goes, the species is restricted to the compact limestones of the middle Productus-limestone, in which beds Mr. Wynne's specimen also was collected. The fragments of stems which I assign to this species are much more common. I collected such specimens at Katta in the compact limestones, in the hills east of Katwáhi and in the Bazáwán.

Remarks.—The genus *Philocrinus* has for a time been identified by Meek with *Erisocrinns*, and thus it might be useful to compare the species of that genus with *Philocrinus cometa*. It has already been shown in the description of the genus that this identification of the two genera was erroneous, and that in fact they deviate widely from each other; as of course do also the species. The same is the case with the genus *Graphiocrinus*, Kon. and also in this case a close comparison of the species is out of the question. It thus appears, that *Philocrinus cometa* is a strongly isolated form in the generic as well as in the specific characters.

As far as is now known, the genus as well as the species seems to be restricted to the Salt-range and has been found nowhere else.

Sub-Kingdom: **CŒLENTERATA.**

(By WILLIAM WAAGEN and JOSEPH WENTZEL, Assisant.)

Class: ANTHOZOA.

Order: ZOANTHARIA.

Sub-order: HEXACORALLA.

Family: *PORITIDÆ*, Dana.

In commencing the description of the *Cœlenterata* it must be remarked that the greater and most troublesome part of the work, the preparation of the materials for microscopical inspection and the arrangement of the plates have been done by Mr. Wentzel, whilst the part taken by Dr. Waagen in the work was restricted chiefly to superintending Mr. Wentzel's labours, and writing the whole work.

Mr. Wentzel took the utmost pains to arrive at fair results, and the microscope slides he prepared for the purpose amount to several hundreds. It is obvious that for such preparations a very long time was needed, and thus there have elapsed nearly three years since the work was begun. A very great advantage of this was, that it was thus possible to select out of the hundreds of slides the specimens suited for representation on the plates, and to get thus really instructive figures.

It must be stated also with thankfulness that Mr. Swoboda spared no pains in representing the often very complicated microscopic objects as correctly and distinctly as possible.

Among the *Cœlenterata* the class of the *Anthozoa* most needs to be considered in detail, and it is largely represented among the palæozoic fossils of the Salt-range. Two orders are present, the *Zoantharia* and the *Alcyonaria*, though the forms we place in the latter have not generally been considered as such.

The *Zoantharia*, so far as they are provided with a solid skeleton, which alone furnishes materials for the palæontologist, can very conveniently be brought into two sub-orders: the *Hexacoralla* and the *Tetracoralla* or *Rugosa*, the other subdivisions as proposed by Edwards and Haime being no longer tenable.

Up to very recent times the *Hexacoralla* have been considered as restricted to the mesozoic formations; only recently, after the affinity of the *Favositidæ* and the *Poritidæ* had been proved beyond doubt, it has been shown that the *Hexacoralla* also reach down far into the palæozoic era.

The *Poritidæ* form as yet a rather large assemblage of forms, having but few characters in common. Zittel in his handbook includes even the whole of the

Favositidæ in the family, but in this respect we prefer to follow the indications given by Nicholson, according to which the *Favositidæ* form a family by themselves. But even after the separation of the *Favositidæ*, the *Poritidæ* still contain so many forms that it is difficult to give a general characteristic of the family.

The most widespread character seems to be the perforated condition of the walls of the corallites. These walls are not perfectly compact, but to a certain extent spongy, and pierced by a more or less large number of mural pores. In the specimens accessible to our observation the primary mural plate cannot be distinguished, the whole wall from one side to the other forming one spongy mass. The septa are generally well developed, but not numerous, partly more or less trabecular. Sometimes large masses of cœnenchyma are intercalated between the corallites. Tabulæ are only exceptionally present. The corallum always forms a massive compact body.

After the *Favositidæ* have been separated from the family, there still remain three sub-families within it, according to Zittel's handbook. All three are very easily distinguishable. The first is the—

Sub-family: *TURBINARIINÆ*, E. & H.

which is characterized by a spongy cœnenchyma, intercalated between the single polypites. The family is chiefly composed of tertiary and recent genera, only some of them are palæozoic, like *Prisciturben*, Kunth, *Palæacis*, E. H., &c. The second is the—

Sub-family: *PORITINÆ*, E. & H.

Also in this sub-family mostly recent and tertiary forms are comprised; but a greater number of mesozoic and palæozoic genera occur in it than in the preceding sub-family. Its chief characteristic consists in the almost entire absence of a cœnenchyma. In this respect it agrees with the next following sub-family, the *Alveoporinæ*, but is distinct from it by the absence of tabulæ.

As regards the genera quoted by Zittel in this sub-family, we must remark, that *Pleurodictyum*, Gdf., is certainly wrongly placed, as it is a genus most nearly related to, if not identical with, *Michelinia*, Kon., and so must be removed to the family *Favositidæ*. The third, the—

Sub-family: *ALVEOPORINÆ*,

is of special interest to us, as it is represented in the Salt-range. The characters of the sub-family are very easily framed. The most characteristic feature consists in the existence of more or less completely developed tabulæ, which, together with the spongy condition of the walls and the presence of trabecular septa, makes a recognition of the genera belonging to it not very difficult. To these characters can be added the inter-mural gemmation of the corallites, that is to say, the propagation

takes place by the wall between two adjoining polypites splitting into two parts, between which a new young polypite is formed. The full definition of this mode of propagation will be given in the introduction to the *Monticuliporidæ*. This mode of augmentation has been figured very clearly by Quenstedt in *Alveopora* (Petrefact. Deutschl. : Koraller, pl. 184, fig. 69 L).

The genera quoted by Zittel as belonging to the sub-family are—

Goniopora, Quoy and Gaimard (recent).
Koninckia, Edwards and Haime (cretaceous).
Favositipora, Kent (recent).
Alveopora, Quoy and Gaimard (recent and tertiary).

To these must be added, according to our view, *Arœopora*, Nicholson, though it has not been so placed by this author. We shall treat more in detail of the systematic position of the genus in the following description.

It is the only genus representing the sub-family in the Salt-range; there are two species.

Sub-family : *ALVEOPORINÆ*, Verrill.

Genus : ARÆOPORA, Nicholson.

The genus was defined by Nicholson in 1879 in his work on the "Tabulate Corals." The characteristic given is as follows :—

"Corallum massive, Favositiform, of polygonal corallites, which radiate outwards from an imaginary axis to open upon the free surface of the colony. Undersurface covered by an epitheca (?). The corallites are firmly united by their walls, which are extensively perforated by apertures, which place the visceral chambers of contiguous tubes in direct communication. Septa trabecular, often irregularly divided, or anastomosing at their free ends. Tabulæ rudimentary, represented only by occasional horizontal trabeculæ. No columella, nor cœnenchyma."

We have made several microscopical preparations of one of the species occurring in the Salt-range, the preservation of which was such as to promise fair results, and from these sections it appears that the characteristic of the genus must be changed to a certain extent in some points to fit the Salt-range species.

No mention is made by Nicholson of the spongy condition of the walls of the corallites, which is a very peculiar character. Generally the walls of the corallites consist of the so-called "primary mural plate," the dark or light coloured line (according to preservation) that in tangential sections forms the middle-line of the walls, and which is followed on both sides by secondary thickening, whereby the wall properly speaking is produced. This primary mural plate is absent in *Arœopora*, at least we could not detect it in any of the sections we made, the whole thickness of the walls of the corallites being made up of a spongy mass, which is often of very considerable thickness, but varies to a great extent in this respect.

The mural pores pierce this spongy mass at very irregular distances, but seem to be on the whole rarer in the Indian than in the Australian species. They bend

most irregularly in all directions, thus forming tortuous canals, which often assume the appearance of intermural canals, as they have been defined by Nicholson. In fact these latter organs are probably in all cases nothing else but the canals of irregularly bending mural pores, as we shall have occasion to show later on in this work.

Another point which has to be rectified is the condition of the tabulæ. They are well developed and quite distinct, not rudimentary, in the Indian species.

A point which has been rightly divined by Nicholson is the existence of an epitheca, which is clearly exhibited by our specimen figured on pl. XCVIII.

The propagation, or gemmation, is an intermural one, as may be seen from figs. 3*a* and *b* on Pl. XCVIII.

The genus has been compared by Nicholson to the more massive species of *Favosites*, like *Fav. hemisphærica*, Yand. and Shum., or more particularly to *Columnopora*, Nich., which is said to possess similarly porous walls of the single corallites.

On p. 32 of Nicholson's Tabulate Corals, however, the genus is also compared to *Alveopora*, which seems to us to express more appropriately the real affinities of the genus than the comparison with *Favosites* and the like.

If we consider the figures given by Nicholson on Pl. VII of his work, we see immediately that the walls of the corallites in *Columnopora* are entirely different in their structure from *Aræopora*, though they may be similarly perforated. But in the tangential sections, figs. 2*a* and *c*, we see very distinctly a primary mural plate and the otherwise compact condition of the wall. There is not a trace of the spongy matter, nor the absence of the primary mural plate, as in *Aræopora*.

In this respect *Aræopora* deviates from all the rest of the *Favositidæ*, and therefore we have thought it proper to remove it altogether from that family. The spongy condition of the walls of the corallites seems to approach *Aræopora* more nearly to the family *Poritidæ* than to any other group of corals, whilst the existence of distinct tabulæ and the trabecular development of the septa indicate a certain affinity of the genus to *Alveopora*, an affinity that has also been recognised by Nicholson. Thus, it cannot be very wrong if we place the genus in the sub-family *Alveoporinæ*. The only doubt that might remain is, whether the genus should not perhaps be better considered as forming a sub-family by itself.

The genus has up to the present only been found in Australia (Queensland), in beds of a doubtfully devonian age. The Indian specimens are met with in much more recent strata, but though two species can be distinguished, yet both are very characteristically different from the *Aræopora australis* as described by Nicholson, as might indeed be supposed from their different geological position.

1. Aræopora tuberosa, Waagen & Wentzel, Pl. XCVIII.

The species forms massive corals of moderately large dimensions, which, on the whole, have a more or less roundish tuberous appearance. They may have been

fixed to some foreign body by part of the under-surface, but the specimens at our disposal do not show this clearly. The whole upper surface and part of the lower one are covered with the closely arranged calices, whilst in places along the margins of the colony a thin concentrically plicated epitheca is developed, which is, however, much worn by weathering. The single corallites all radiate from an imaginary short axis or centre of the colony, but are otherwise rather irregularly arranged, bending in various directions. The calices are on an average about 2mm. in diameter, but on the whole very irregular in size and shape. There are always small calices of young animals disseminated between larger ones. The irregular trabecular septa can be well seen within the calices. The calices are separated from each other by rather thick walls, on which little pores are irregularly disseminated.

As regards the internal structure, the most strange and characteristic feature, the spongy condition of the walls, has been mentioned already in the description of the genus. The mural pores are not very numerous, are very irregularly arranged, and form, according to the thickness of the walls, narrow canals, which generally bend in various directions, and are thus more often cut transversely by thin sections, forming round holes somewhere within the substance of the walls, than longitudinally piercing the wall from one end to the other. The trabecular septa are of such an excessive irregularity that, in thin sections, they sometimes appear quite separated from the wall, which is caused by their bending upward and extending to near the middle of the tube of the corallite as tooth- or thorn-like projections. The tabulæ are complete, not very numerous, much more regular than the walls, and mostly bending upward.

Locality and geological position.—This is a very rare species; there is only a single specimen of it preserved among the Salt-range materials. It comes from Dr. Verchere's collection, and was certainly found somewhere in the Rotta Roh range, though the exact locality is not known. The specimen is entirely calcareous, and comes beyond doubt from the middle division of the Productus-limestone.

Remarks.—In general appearance the species seems to be rather nearly related to *Arœopora australis*, Nich., as the latter has likewise a tuberous or pyriform shape. On a close examination the distinction of the two forms is, however, very easy. The Indian species appears to be much clumsier in its general appearance, the walls of the corallites are thicker, and if thin slides are examined with the microscope it is found to possess perfect tabulæ, whilst these are imperfect in *Arœop. australis*.

These characters suffice to distinguish between the two species. There is no other form to which the present one could be compared, except the following :—

2. Arœopora ramosa, Waagen & Wentzel, Pl. CVI, figs. 8-9.

Corallum massive, arborescent, probably attached with its base to foreign bodies. The branches are thick, up to a diameter of 50 to 70mm., but generally

much thinner (about 30-40mm). The branching is regularly dichotomous. The branches are generally not round but laterally compressed, so as to have an oval section; they are also not quite straight, but variously bent and twisted. The corallum seems to have grown to a large size; but there are only fragments preserved in the Salt-range collection, so it is impossible to say what dimensions it really attained. It seems not improbable that the entire arborescent colonies may have attained a height of half a metre. There is not a trace of an epitheca on any of the specimens at disposal. The entire branches are composed of very numerous approximately cylindrical or polygonal corallites, which radiate from an imaginary axis, ascending and diverging by degrees. The whole surface of the branches is covered by not very large calices. They are irregularly polygonal or roundish, and of rather unequal size, on an average, however, about 3mm. in diameter, separated from each other by rather thick porous walls. The smaller calices disseminated between the larger ones indicate probably the existence of young corallites. The septa are rudimentary, very irregular, and represented only by thorny processes, extending into the visceral chamber of the corallites.

Of the internal structure of this species we know but very little. All the specimens are preserved in such a manner that it was found impossible to make microscopic preparations. Either the whole specimen is impregnated with silica so that it forms one siliceous mass and nothing can be distinguished, or the visceral chambers of the corallites are filled with sandy matter, and their walls are then brittle to such a degree that it is impossible to make a thin section.

Locality and geological position.—This species is much more common than the preceding one, but it is at the same time restricted to the upper division of the Productus-limestone. It has been found in this geological position by myself west of Khura (4 sp.), at Jabi (1 sp.), and at Chidru (1 sp.), in the Cephalopoda-bed; Mr. Wynne brought the species from Vurcha (1 sp.), from the Bazárwán (1 sp.), from Jabi (1 sp.), and from Chidru (1 sp.).

Remarks.—Though the microscopical inspection of this species has failed, yet there cannot be any doubt that the form here under consideration is congeneric with the preceding one; the spongy condition of the walls of the corallites can be seen in it, even on weathered surfaces.

Also specifically the present species seems to be very nearly related to the preceding one. It differs, however, from the latter by the arborescent shape of the corallum, and also apparently by, on an average, somewhat larger calices, though it is rather difficult to decide on this point, as the size of the calices is so very variable.

On the whole, it is highly probable that we have to deal here with a separate species, as not only there exist differences between the two forms, but also the geological positions of the two are different, *Arœop. tuberosa* being restricted to the middle, and *Arœop. ramosa* to the upper division of the Productus-limestone.

Family: *FAVOSITIDÆ*, Nicholson.

The family has been characterised by Nicholson in the following manner:—

"The corallum in this family is of very variable form, but is composed of polygonal or sub-cylindrical corallites, which are usually in close contact throughout their entire extent, and are furnished with well-developed walls. The walls are, however, perforated by a greater or smaller number of rounded apertures—the mural pores—by which the visceral chambers of contiguous polypites are placed in direct communication. There is no true cœnenchyma; and the condition of the septa is extremely variable, these structures being sometimes obsolete (some forms of *Trachypora*, &c.), sometimes in the form of marginal lamellæ or ridges (*Nyctopora*, Nich.), and most commonly represented by vertically disposed rows of spinules (most species of *Favosites*). The tabulæ are usually well developed and complete, but they are sometimes imperfect (*Favosites hemisphærica*, Yand & Shum.)"

To this admirably clear characteristic of the family nothing has to be added. The distinction of the family from the *Poritidæ* appears on a first glance to consist in the perfect walls of the single corallites in the *Favositidæ*, where each single individual has its proper, perfectly developed wall, whilst the line of junction, where the walls of two adjoining corallites are united, forms what is generally called "the primary mural plate," or "primordial wall." This plate appears rather differently in different specimens, according to preservation, and even in one and the same specimen its appearance is often very different. Mostly it can be seen under the microscope as a dark or even black line, separating the walls of adjoining corallites, but often this dark line is replaced by a light-coloured one, and then its distinction is often so vague that it appears as if the two adjoining walls were perfectly united and grown together without distinction. This latter appearance depends, however, solely upon the preservation. Lastly, a third mode of appearance is brought about by the primordial wall being preserved partly as dark, partly as light-coloured substance, whereby it then appears as a series of black points.

The secondary thickenings of the walls of the corallites in the *Favositidæ* are built up of transversely arranged fibres.

The propagation, or gemmation, of the *Favositidæ* is an intermural one; that is to say, in that part of the soft animal matter covering the outside of the whole corallum, and, corresponding to the primary mural plate of the calcareous parts, a new individual takes its origin. It is formed by gemmation on the outskirts of one of the adjoining individuals, and when the calcareous wall begins to be formed, the primary mural plate, extending between the two old individuals, is caused by this new one to split in two and thus to make room for the new intruder. As the whole process of gemmation is thus restricted to the soft parts of the colony, and the calcareous parts only take part in the process after the new individual has already been separated from the old one, it is very natural that it afterwards becomes impossible to say from microscopical inspection of the calcareous corallum alone

from which of the two adjoining old individuals the new one took its origin. All that has been said of the soft parts is, as may be supposed, purely hypothetical, but it is the only way of explaining the fact that it is never possible to say from which individual a new one may have taken its origin. In the description of the *Monticuliporidæ* we shall have occasion to recur to this subject.

Another mode of propagation that also occurs in the *Favositidæ* is that of simple fission of an old individual by splitting in two (fissiparity). A vertical wall begins to be formed on one side of an individual, stretching forth into the visceral cavity and by and by dividing it into two. This mode of propagation is, however, rather rare; only in the genus *Cœnites*, Eichw. it seems to be the rule.

The number of forms belonging to the family *Favositidæ* is rather large. In Zittel's handbook, we find not more than eight genera enumerated within the family, other genera which must now be included in the family being put into the family *Pocilloporidæ*, or partly even among the *Bryozoa*.

The knowledge of the family has been enormously extended by the investigations of Prof. Nicholson. He enumerates not less than 24 genera within the family of which, however, not all can be retained in it. According to what has been said with regard to the preceding family (the *Poritidæ*) the genera *Favositipora*, Kent., and *Arœopora*, Nich., must be the first excluded. Then also *Stenopora*, Lonsd., cannot, according to our investigations, be retained in the family *Favositidæ*, but must be removed to the *Monticuliporidæ*.

There will still remain not less than about nineteen genera, which with more or less certainty belong to the family.

Nicholson himself has already given some hints as to a grouping of the genera, and chiefly one group of forms he circumscribes more in detail; this is the one composed of the genera *Pachypora*, Lindst., *Striatopora*, Hall, *Trachypora*, E. & H. *Dendropora*, Mich., and *Cœnites*, Eichw. Another group seems, according to him, to be constituted by *Syringolites*, Hinde, and yet another one by *Nyctopora*, Nich. We cannot in all these respects agree with Mr. Nicholson. The genus *Nyctopora* is separated from the remainder of the *Favositidæ* by the circumstance that in this genus the primary mural plate, generally so conspicuous in the genus *Favosites*, is not distinguishable. If one considers, however, in what large degree the distinctness of this primary mural plate depends upon the mode of preservation of the specimens, it may perhaps be prudent to separate the genus *Nyctopora* for the moment, yet not entirely, from *Favosites* by putting it in a quite different division of the family. The propriety of separating *Pachypora* and allied genera from *Favosites* may also be questioned, as recently Mr. Frech has even opposed the idea of considering the two as different genera; but that this can be done quite safely we shall have occasion to show presently. Mr. Nicholson's grouping of *Pachypora* and allied genera in opposition to *Favosites*, etc., may however be accepted for the present, though it cannot be denied that *Pachypora* and *Favosites* are very near relations.

On the whole, it appears to us that very conveniently five sub-families may be distinguished within the family *Favositidæ*.

I. Sub-Family: *FAVOSITINÆ.*

In the genera belonging to this sub-family the corallites mostly have thin walls, and (mostly) complete, straight, not cystoid tabulæ. We consider the following genera as belonging to it.

1. Favosites, Lam., 1816: Hist. des Anim. sans Vert., vol. II, p. 204. Silurian to carboniferous. As a sub-genus there might, perhaps, be retained Emmonsia, E. & H. 1851: Pol. Foss. des Terr. paléoz.
2. Romingeria, Nichols., 1879: Tabulate Corals, p. 114. Devonian.
3. Vermipora, Hall, 1874: Twenty-sixth Ann. Rep. State Cab. of New-York, p. 109. Silurian and devonian.
4. Nyctopora, Nichols., 1879: Tabulate Corals, p. 182. Lower silurian.
5. (?) Nodulipora, Lindström, 1873: Ofversigt af Kongl. Vetensk. Akad. Forhandlingar, No. 4, p. 14, note. Upper silurian. (The position of this genus is uncertain.)
6. (?) Billingsia, Koninck, 1876: Rech. Foss. Paléoz. de la Nouv. Galles du Sud, I. p. 75, Pl. II, fig. 4. Devonian (position uncertain).

II. Sub-Family: *TRACHYPORINÆ.*

This sub-family is characterised by having the walls of the corallites very much thickened on the inside. The tabulæ are complete, straight, not very numerous. The following genera may be considered as belonging to it.

1. Pachypora, Lindström, 1873: Ofversigt af Kongl. Vetensk. Akad. Forhandlingar, p. 14. Silurian to permian.
2. Striatopora, Hall, 1882: Palæont. of New-York, vol. II, p. 156. Upper silurian and devonian.
3. Trachypora, E. & H., 1851: Polyp. Foss. des Terr. Paléoz, p. 305. Devonian.
4. (?) Laceripora, Eichwald, 1860: Leth. Rossica, p. 490. Silurian (?) and carboniferous (?) (position uncertain).

III. Sub-Family: *MICHELINIINÆ.*

In the genera belonging to this sub-family the walls of the single corallites are thin, and often much perforated. The tabulæ are numerous and strongly cystoid. Calices generally large. The genera belonging to it are the following:—

1. Columnopora, Nichols., 1874: Geolog. Mag., new ser., Vol. I, p. 253, fig. 1. Silurian.
2. Michelinia, Koninck, 1842: Anim. Foss. des Terr. Carb. de la Belgique, p. 29. Silurian (?) and carboniferous.
3. Pleurodictyum, Goldf., 1829: Petrefact. Germ., I, p. 113. Silurian (?) and devonian. (Perhaps identical with the preceding.)
4. Chonostegites, E. & H., 1851: Polyp. Foss. des Terr. Paléoz., p. 299. Devonian. The position of this genus is very doubtful. It possesses a stolonal gemmation, and thus should perhaps be considered as belonging to the *Alcyonaria*.
5. (?) Beaumontia, E. & H., 1851: Polyp. Foss. des Terr. Paléoz., p. 276. Devonian and carboniferous (position uncertain).

IV. Sub-Family: *SYRINGOLITINÆ.*

The few genera that compose this sub-family are characterised by the thin walls of the corallites and funnel-shaped tabulæ, which touch each other in the middle and thus form a central tube.

There are only two genera which possibly might be placed in this sub-family:

1. Syringolites, Hinde, 1879: Geolog. Mag., Dec. II, vol. VI, p. 244. Silurian.
2. (?) Roemeria, E. & H., 1851: Polyp. Foss. des Terr. Paléoz., p. 253. Devonian (position very uncertain).

V. Sub-Family: *ALVEOLITINÆ.*

The forms belonging to this sub-family are characterised by corallites which are not strictly cylindrical or polygonal, but more or less compressed, triangular, or semilunar in the transverse section. The walls of the corallites are sometimes thickened, sometimes not. Septa mostly rudimentary, sometimes one or two slightly indicated.

There are, as it seems to us, only two genera belonging to this sub-family:

1. Alveolites, Lam., 1801: Syst. des Anim. sans Vert. p. 375. Silurian and devonian.
2. Cœnites, Eichw., 1829: Zool. special, t. I. p. 179. Silurian and devonian.

The family *Favositidæ* is but sparingly represented in the Salt-range. Only two genera belonging to it are in the collection, and even these are not very common.

The genus *Pachypora* is represented by two species, whilst the genus *Michelinia* appears with more massive forms, taking part in the composition of the coral-reefs which occur off and on in the middle region of the Productus-limestone. This latter genus has furnished four species.

Sub-Family: *TRACHYPORINÆ.*

Genus: PACHYPORA, Lindström.

The available materials of this genus from the Salt-range were very scanty, and only of one species a sufficiently large piece was at our disposal for microscopical sections. These, however, prove to be very instructive, and elucidate many points, the discussion of which is of interest.

Regarding the generic position of these specimens, there seems to us even some slight preliminary doubt as to whether we have to deal here with a true *Pachypora*. The distinction of *Pachypora* from *Favosites* seems to be not in all cases easy, and it has been advocated by Frech that the two genera should be considered entirely identical. The reasons brought forward by Dr. Frech are beyond doubt well founded for the case he treats of, but we should not like to generalise the question so far as he does. Before all it seems to us that the genus *Pachypora*

is not founded solely on the thickening of the walls of the single corallites, though this is the most striking character, but the distinction rests also in the larger and more irregularly distributed mural pores in *Pachypora* than is generally to be observed in *Favosites*. Thus, in some species of *Favosites*, although the walls of the corallites may sometimes become thickened, this does not seem to us a sufficient reason for uniting all species of *Pachypora* with *Favosites*.

These special characters of *Pachypora* are very well exhibited by the microscopical sections we have represented on Pl. XCVII: that not only the thickened walls of the corallites are most distinctly developed, but also the characters of the mural pores can be very well distinguished. The large size of them is on a first glance very remarkable, and as regards their distribution, we see in all the figures that this is very irregular, and in figure 3*b* that some corallites show a biserial, others a uniserial, arrangement of these pores. From this it appears that we have certainly to deal in this case with a true *Pachypora*.

All the sections are, however, taken from one species. With regard to the other species occurring in the Salt-range, we cannot say anything definite. We place it in the genus *Pachypora* only on account of its outward appearance.

Of other interesting points observable in the sections the condition of the primary mural plates may be particularly mentioned. We see in the figures on Pl. XCVII that the appearance of these organs is very different according to different modes of preservation. In the Figs. 1*c*, 3*a*, and 3*b* the primary mural plates separating the single corallites and forming the middle line of the thickened walls, appear as dark lines, mostly distinctly defined, sometimes however rather diffuse. In fig. 3*c*, on the contrary, the primary mural plates appear as white lines with darker margins. These margins are absent in the lower part of the same figure, and the primary mural plate is represented only by a light-coloured zone. We must lay some stress on these different modes of preservation of the primary mural plates, as in the *Monticuliporæ* similar phenomena are very often to be observed, and it is of importance to find the same facts in *Pachypora*, an undoubted coral.

Another fact which requires some words of explanation is the mode of appearance of the mural pores in the different preparations represented on Pl. XCVII. In this respect chiefly fig. 3*a* is very instructive. We see that the mural pores are the entrances to long tortuous canals, one or the other of which often bends in such a way that it terminates suddenly with a round pore, as always happens when the canal is cut by the thin microscopical slide transversely, instead of longitudinally. Quite the same can occur also in tangential sections; then we have round pores within the substance of the wall, assuming the appearance as if a vertical canal extended within the wall, an appearance which perfectly agrees with what has been called by Nicholson "intramural canals." It appears to us highly probable that Mr. Nicholson s intramural canals are nothingelse than such tortuous mural pores which happened to be cut transversely, instead of longitudinally, in some of his microscopical sections.

The intermural gemmation, or propagation, of these forms can also be well observed in the thin sections represented on Pl. XCVII, figs. 3*a*, *b*, *c*, and 1*c*.

As has been stated above, the genus is represented in the Salt-range by two species, which are both new to science. They were found in one and the same bed, in the Cephalopoda-bed of the upper Productus-limestone at Jabi.

1. PACHYPORA CURVATA, Waagen & Wentzel, n. sp., Pl. XCVII, figs. 1 & 3.

The corallum is massive, forming apparently simple, undivided stems, more or less round in section. These stems do not become very thick, their maximum diameter is about 10mm. The corallites are numerous, of very unequal size, their orifices forming round pores of never more than one millimetre in diameter on the surface of the stems, and covering this surface entirely. The walls of the corallites are quite enormously thickened, and this nearly for their entire extent. This thickness of the walls causes the calices to be rather far apart from each other. The space between is carinated in the middle. The corallites take their origin in the middle of the stems, and radiate in ascending, slowly at first and then rather suddenly bending round towards the surface of the stems. Of septa properly speaking nothing can be observed; they are apparently replaced by the so-called septal spines, which are exceedingly strongly developed in the present species, but can be observed only on thin sections. Tabulæ are of extremely rare occurrence.

Locality and geological position.—There is a single specimen of this species contained among the materials from the Salt-range. This was collected at Jabi in the Cephalopoda-bed of the upper Productus-limestone.

Remarks.—This is one of the most typically developed species of *Pachypora* imaginable. It is distinct from all the species hitherto described, by the extreme scarcity of tabulæ. So much the more are the so-called septal spines developed, and it might even be questioned whether in this case these spines ought not rather to be considered partly as incomplete tabulæ. They are extremely irregular, bending in every direction and often uniting from opposite sides of the corallite.

Of previously described species chiefly *Pachypora nicholsoni*, Frech.(=*Pachyp. cervicornis* (Blainv.) Nichols.), from the devonian of the Eifel, may be compared; it needs only a look at Nicholson's excellent figures to see how closely the two forms are related to each other. Of identity there can, however, be no question, as the Indian species has very considerably larger calices than the devonian one.

Another species which perhaps might be compared is *Calamopora mackrothi*, (Gein.) King. If Mr. King's indications with regard to this form are right, and we have not any reason to doubt them, then the above name cannot stand, as *Stenopora mackrothi*, Geinitz, is something quite different from what has been described by King under the name. Then the species will have to be called *Pachypora ? independens*, King (1848, Catalogue, p. 6). It is probably a *Pachypora*, though we cannot be sure on the matter, as we have no materials of the species; but if so, it

seems to be rather nearly related to our *Pach. curvata*. It is a ramose species, like the Indian one, but the corallites seem also to be on an average smaller, and thus the similarity is only a rather distant one.

2. Pachypora jabiensis, Waagen & Wentzel, n. sp., Pl. XCVII. fig. 2.

Our only specimen, and that a small one, of this species is very perfectly preserved; and though, owing to the scantiness of the material, we were not in a position to make thin sections, yet most of the characters of the species can be made out.

The corallum is massive, not very large, of an irregularly tuberous shape, taking rise from the edge and both faces of a small shell fragment. The whole surface is covered with the calices of the single corallites, which are very irregular in size, more or less polygonal in shape, and never possessing a diameter of more than 1·5mm. These calices are separated from each other by rather thick walls, with high sharp crests in the middle.

The interior of the corallites is partly exposed for a certain distance, the strong matrix having been removed out of them by weathering. It can thus be seen that the walls have extremely large, irregularly arranged, mural pores, and that the inside of the walls is ornamented at irregular distances by rounded protuberances, which assume somewhat the appearance as if the corallites were provided with irregular septa.

The mode of augmentation of the corallites can also be well observed. Both the modes of propagation described in the introduction to the family as occurring in the *Favositidæ* are represented on our specimen. Generally the mode of gemmation is the intermural one, but in one or two cases very distinctly fissiparism can be made out.

Locality and geological position.—The single specimen of this species existing in the Salt-range collection was found in the Cephalopoda-bed of the upper Productus-limestone of Jabi.

Remarks.—The position of this species in the genus *Pachypora* cannot be considered as above every doubt, until the microscopical inspection of it can be executed. For the present this position seems the most probable one, according to the characters which have been indicated in the above description.

Of species previously described the one quoted by Beyrich as *Calamopora* sp., from carboniferous beds of the island of Timor, must chiefly be compared. In that form the calices are of about the same diameter as in the Indian specimen; they are also polygonal, and thorn-like processes are observable on the inside of the walls of the single corallites here and there. The entire shape of the corallum seems also to be more or less tuberous. An exact identification of this form with the Indian one, however, cannot be made because the mural pores have not been observed in the specimens from Timor.

Other carboniferous species, chiefly those from the mountain-limestone, can barely be compared with the present form. *Favosites haimeana*, Kon., has similarly large cells, but the walls of the corallites are quite thin, and the corallites are very long.

Sub-Family: *MICHELINIINÆ.*

Genus: MICHELINIA, Koninck.

To the excellent characteristic of the genus, as framed by Nicholson, but very little is to be added. All that still needs mentioning is the mode of gemmation, which has not been taken notice of by Mr. Nicholson. As in *Favosites* the general mode of gemmation is the intermural one. This can be well observed in our figure 1*c* on Pl. XCIX, where on the upper end a new individual is seen taking its origin. This increases very rapidly in size, causing the adjoining corallites to deviate from their original direction.

This identity of the mode of gemmation in *Michelinia* and *Favosites* is one proof more that the two genera are very nearly related, though this has not been admitted by Lindström, Zittel, and others. The reasons for which Lindström places the genus *Michelinia* in the *Cystiphyllidæ* are, the cystoid condition of the tabulæ, the existence of septa in the corallites, and of root-like appendages on the epitheca, and the different morphological interpretation that must be given to the mural pores in the two genera.

As regards the last of these characters we must confess that on thin sections we could not find any difference between the mural pores of *Favosites* and *Michelinia*, either in the figures given by Nicholson (of *Pleurodictyum*) or in preparations we made ourselves. The pores show no regularity whatever in their arrangement, and do not take any heed of the septal furrows which stretch down the walls of the corallites. They pierce these walls directly, and in many of our preparations of silicified specimens a hair can easily be passed through them. They are not all absolutely of the same size; some are larger, some smaller. They are often more clustered together at the base of young individuals which have just taken their origin by gemmation, and thus still communicate freely with the parent individuals.

If thus the mural pores do not seem to warrant a wide separation of *Michelinia* and *Favosites*, the other characters alluded to by Mr. Lindström are still less adapted to make such a separation acceptable. The septa are never developed, but appear as very shallow elevations, separated from each other by barely perceptible furrows, stretching down the internal sides of the walls of the corallites. Since the investigations of Mr. Nicholson however it is known that in certain forms of undoubted *Favositidæ*, as in *Nyctopora*, the septa are at least as well developed, and thus this rudimentary development of septa in *Michelinia*, which is, moreover, often entirely absent in some forms of this genus, cannot be considered as forming a fundamental difference between it and *Favosites*.

As to the cystoid condition of the tabulæ, it must be confessed that such a thing has never been observed in *Favosites* proper; on the other hand, in *Columnopora* a form has been described as truly transitional between *Michelinia* and *Favosites*. In this form the tabulæ are mostly convex, or even partly cystoid, the walls of the single corallites are still more frequently pierced by mural pores than in *Michelinia*, and there are traces of septa developed on the inside of the tubes of the corallites. Thus it can hardly be doubted that *Columnopora* is about equally nearly related to *Michelinia* and to *Favosites*, and the existence of such a transitional form goes far to elucidate the relation of those two genera.

As a last differental character between *Favosites* and *Michelinia* the existence of an epitheca provided with root-like appendages is quoted by Lindström. That in *Favosites* also an epitheca is sometimes developed had been already observed by Quenstedt (Petref. Deutschl., Vol. VI, p. 5). The root-like appendages, however, even in the genus *Michelinia*, only occur in that group of forms of which *Michelinia favosa*, Gdf., is the prototype. In all the other groups these appendages are absent.

Moreover, even if the points of discrepancy are not of such a nature as to warrant a fundamental distinction of *Michelinia* and *Favosites*, there are points of similarity which cannot be overlooked. One of these is the mode of gemmation, which is absolutely identical in *Favosites* and *Michelinia*. On the surface of the corallum the new individuals appear as small, three-, four-, or five-sided calices at the points where three old corallites come together. That the gemmation is truly an intermural one, and that it cannot be stated from which of the old corallites the new one has taken its origin appears beyond doubt from the section represented in fig. 1*c*. Pl. XCIX, where the primordial wall that separates the old corallites is distinctly split into two at the point where a new one takes its origin.

After all that has been said there cannot, it seems to us, remain much doubt that *Michelinia* must be placed in the family *Favositidæ*.

Very nearly related with *Michelinia* is *Pleurodictyum*, which thus cannot be placed, as Zittel advocates, near *Porites* or *Protaræa*. *Pleurodictyum*, if it is at all different from *Michelinia*, deviates from that genus chiefly only by the less frequency of tabulæ in the single corallites.

Just the contrary is the case with *Chonostegites*, E. & H., which has been considered as a synonym of *Michelinia* by Zittel and others. The characters of the genus have been well set forth by Nicholson; one character has not, however, been sufficiently brought forward by him, though it is very clearly represented in his drawings, and also mentioned casually in the description; this is, the "stolonal gemmation,"—as it has been called by Koch in his very important paper on the modes of propagation occurring in corals—, which is very distinctly developed in this genus. This "stolonal gemmation" is characteristic of the *Syringoporidæ* and of *Tubipora*, whilst it generally does not occur in the *Zoantharia*, and thus the genus may perhaps have to be altogether removed from that class and placed in the

Alcyonaria. If then we allow *Chonostegites* to remain in the vicinity of *Michelinia*, it is only provisionally, and on account of the perforation of the walls of the single corallites, which occurs rather frequently in this genus.

The genus *Michelinia* has, up to the present, been observed to occur chiefly in the carboniferous formation; in devonian strata also species of the genus have been found. That the genus occurs again in permian beds has been proved by the detection of specimens by Abich in the permian beds on the Araxes.

In the Salt-range the genus is not at all rare, and occurs most commonly in the middle division of the Productus-limestone, which is made up in a great part of coral reefs; also in the upper division specimens of the genus are not very rare. In the lower division, however, it has not yet been found up to the present.

There are altogether four species of the genus contained in the Salt-range collection. Two of them, *Mich. abichi*, W. & W., and *Mich. placenta*, W. & W., occur in the upper division of the Productus-limestone, whilst the third and fourth, *Mich. indica*, W. &. W., and *Mich. glomerata*, McCoy, are restricted to the middle division.

1. Michelinia abichi, Waagen and Wentzel n. sp.

1878. *Michelinia tenuisepta*, (Phill.) Abich: Bergkalkfauna aus der Araxesenge bei Djoulfa, p. 91, pl. 11. fig. 11 (*non* Phillips).

1879. *Michelinia sp. indet.*, Möller: Neu. Jahrb. für Min., 1879, pp. 238-239.

? 1883. *Michelinia sp.*, Kayser: Fauna von Lo-Ping; Richthofen's China, vol. IV, p. 195, pl. XXIX, fig. 15.

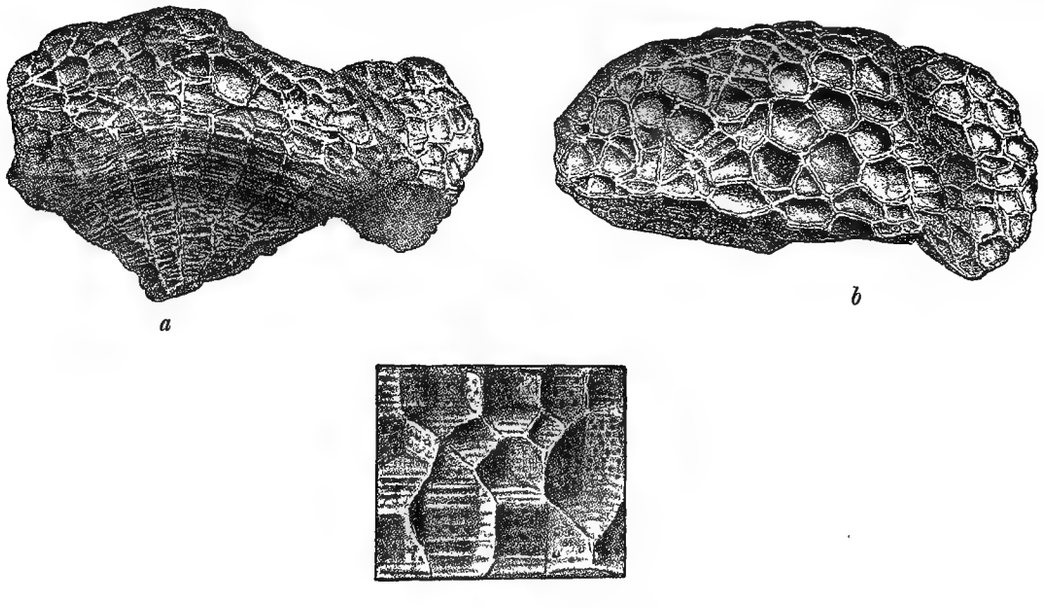


Fig. 26, Michelinia abichi, Waagen and Wentzel n. sp. Silicified specimen of an entire corallum from the upper Productus-limestone of Kafirkot North: *a*, lateral view; *b*, top-view, both natural size; *c*, some of the calices broken and exposing their lateral faces, enlarged.

Corallum irregularly reversed conical in shape, with an infundibuliform base, which is attached by the median prominence to foreign bodies and otherwise covered

by a not very thick concentrically plicated epitheca. Up to the present, no large specimens of this species have been detected, and it is probable that it never much exceeded the size of the figured specimen. Corallites spreading from the place of attachment, ascending at the same time steeply. Their form is irregularly polygonal. The marginal ones are covered by the epitheca in such a manner that their longitudinal extension can be distinguished through it. All the corallites are in close contact, their walls rather thin and not perfectly combined together but showing distinctly in the middle the primary mural plate. Calices very irregularly polygonal in outline, rather small, never larger than 5mm. in diameter, often very much smaller, shallow. Septa indicated by a close but rather indistinct vertical striation of the interior side of the walls. Mural pores not very large, numerous, irregularly arranged. Tabulæ not very numerous, about two to three within the space of 5mm., cystoid, not very strongly vaulted, irregular, often uniting with one another, or with smaller cysts attached parasitically on the margins of the larger ones.

Locality and geological position.—There is only one specimen of this species preserved in the Salt-range collection. This was collected by Mr. Wynne in the trans-Indus continuation of the Salt-range at Kafirkot North, in the higher divisions of the Productus-limestone.

Remarks.—We identify this fossil from the Salt-range with the one that has been described by Abich under the name of *Michelinia tenuisepta*, Phill., from the upper palæozoic (permian) beds of Djoulfa on the Araxes. It cannot be subject of the slightest doubt that this form is very nearly related to the true *Mich. tenuisepta*, and there are perhaps many palæontologists who would not advocate the distinction of the Armenian and Indian fossils from Phillips's species. Already however, Möller has drawn attention to the circumstance that in Abich's specimen the calices are considerably smaller than in the typical mountain-limestone species. As the same character is repeated in the Indian specimen, which is of similar geological age as the Armenian one, it seems now probable that a permian form exists which is on the whole very similar to *Mich. tenuisepta*, Phill., but which can be distinguished by altogether smaller calices. To this form we have given the name of *Mich. abichi.*

A fossil which seems to be very similar to this *Mich. abichi*, but which has only been found up to the present in a very bad state of preservation, is the one figured by Kayser from the upper coal-measure beds of Lo-Ping in China. The size of the calices is absolutely the same, and thus it might very easily be the case that we have to deal here with the same species. The question can, however, not be decided before better materials from China are available. If the identity should prove to exist in reality, then the species would have a rather wide geological range, from upper carboniferous to permian.

On the whole it is highly probable that *Mich. tenuisepta* is the direct ancestor of *Mich. abichi*, and that thus both belong to one and the same developmental series.

2. MICHELINIA PLACENTA, Waagen and Wentzel n. sp.

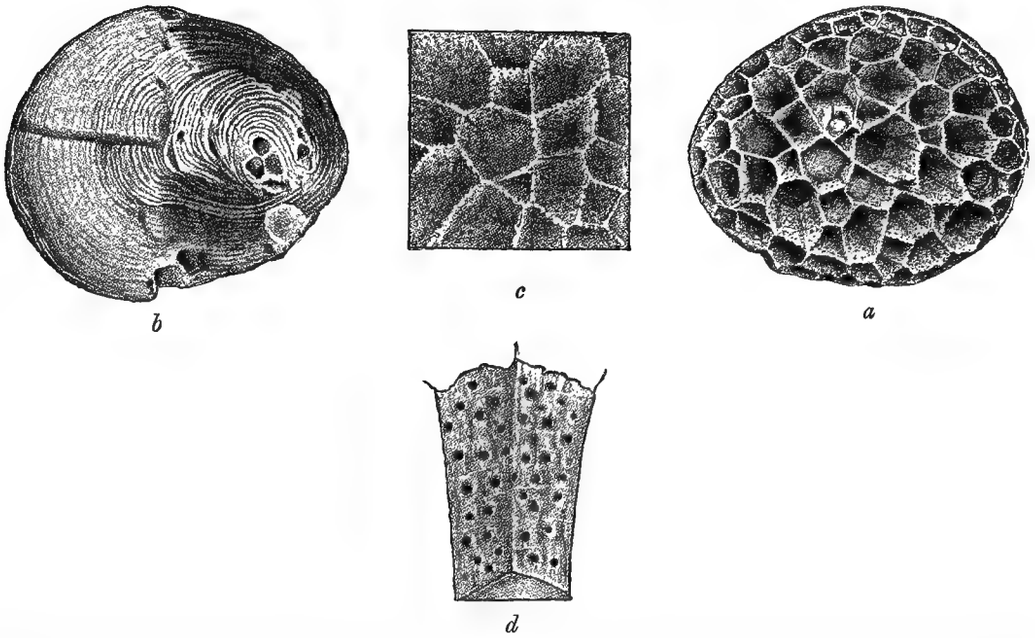


Fig. 27, MICHELINIA PLACENTA, Waagen and Wentzel n. sp. Silicified specimen from the Cephalopoda bed of the upper Productus-limestone of Jabi:—*a*, top-view; *b*, basal-view, both natural size; *c*, some of the corallites enlarged; *d*, walls of one of the corallites strongly enlarged.

Corallum forming flatly lenticular or somewhat conical masses, with a perfectly flat base and slightly elevated corallites. The base is free, fixed only by a small point to foreign bodies and covered with a very thick rugose epitheca. The whole corallum is of rather moderate size. Corallites short, springing under obtuse angles from the flat base, essentially polygonal, and being for their whole extent in close contact together. Their walls extremely thin and brittle, as thin as paper. Calices distinctly polygonal, deep, very irregular in shape and unequal in size, but never larger than 6mm. in diameter, augmenting very distinctly by intermural gemmation. Septa indicated by a rather indistinct vertical striation of the walls of the corallites, but their number cannot be counted. Mural pores very numerous, not very large and quite irregularly disposed. Tabulæ not very numerous, not strongly inflated, but rather flat, mostly complete, sometimes forming small marginal cysts, not filling the entire room of the corallites.

The specimens at our disposal do not exceed a diameter of 40mm. and do not attain a greater height than 15-20mm.

Locality and geological position.—There are altogether two specimens of this species preserved in the Salt-range collection, which were both found in the Cephalopoda-bed of the upper Productus-limestone of Jabi.

Remarks.—With regard to some characters the present species seems to be again most nearly related to *Mich. tenuisepta*, Phill., with which species it chiefly

agrees in the size of the calices, and the vertical striation of the walls of the corallites. It is, however, distinct from Phillips's species by its flat base and the therefore not reversedly conical shape. By these characters the species rather closely approaches *Mich. favosa*, Gdf., which is, however, distinct by the root-like processes which spring from its base.

Of other species, chiefly *Mich. abichi*, described above, must be compared; the distinction of the present species is, however, not difficult; the flat base, the quite different mode of growth, and the larger calices distinguish this form readily from *Mich. abichi*.

3. Michelinia indica, Waagen and Wentzel, n. sp., Pl. XCIX, fig. 1.

A corallum forming irregular tuberous masses of rather large size, which generally spring from a small, reversedly conical base, covered by a thick epitheca; the basal part is, however, mostly obliterated. Corallites tolerably long, polygonal, indistinctly radiating from an imaginary point; their walls are in close contact throughout and rather thick. Calices not deep, polygonal, four-, five-, or six-sided; on an average 6-8mm. in diameter, rarely somewhat larger. Septa almost entirely absent, and even the vertical striation of the walls of the corallites, by which the septa are represented in most species of *Michelinia*, are barely observable. Mural pores very numerous, rather small, and quite irregularly arranged. Tabulæ very numerous, very strongly inflated, forming highly vaulted cysts, which are very conspicuous; they are mostly complete, but sometimes a number of smaller cysts surround a larger median one. The augmentation of the corallites by intermural gemmation is very distinct. The species attains rather large dimensions. Our largest specimen is 130mm. in diameter.

Locality and geological position.—The present species seems to be restricted to the middle division of the Productus-limestone, where it takes part in the formation of the large coral reefs which are to be observed at certain localities in these beds. It has been found in this position at Virgal in the coral-limestone (1 specimen); east of Katwáhi in the same beds (1 specimen); and in the section at Khura in the top-beds of the middle division.

Remarks.—The form which seems to be most nearly related to *Mich. indica* is *Mich. glomerata*, M'Coy, from the mountain-limestone of Europe. The general appearance of both species is absolutely identical, but on a closer examination one finds that the Indian coral has larger calices, 6-8mm. in diameter, whilst they are only 5 to 6mm. in *Mich. glomerata;* the tabulæ also are much more numerous and much more irregular, so that it very probably forms a different species.

Mich. tenuisepta and the two species described on the foregoing pages are also rather nearly related to our *Mich. indica*, but from all these the latter is distinguished by its entirely different mode of growth, which makes it resemble *Mich. glomerata*.

There can be but little doubt that *Mich. glomerata* is the direct ancestor of *Mich. indica*, but it appears difficult to adduce undoubtable proofs for such a supposition.

4. Michelinia cf. glomerata, M'Coy, Pl. CXVI, fig. 1.

1855. *Michelinia glomerata*, M'Coy: Brit. palæoz. Foss., p. 80., pl. IIIB, fig. 14.

There is a very large coral in the Salt-range collection that may perhaps be directly united with *Mich. glomerata*, M'Coy. The general form of the corallum is irregular, forming large flatly tuberous masses of 170 to 200mm. diameter. Corallites not very long, radiating from an imaginary point. Calices polygonal, of rather unequal sizes, but never larger than 5 to 6mm., tolerably deep; the walls not very thin, and without vertical striation in the specimen at our disposal. Mural pores not very conspicuous. Tabulæ rather straight, very numerous, four to six within the distance of 5mm., sometimes with little vesicles along their margins. Intermural gemmation very frequent and distinct.

Locality and geological position.—The only specimen of this species in the Salt-range collection was found by Mr. Wynne in the middle division of the Productus-limestone at Morah. The specimen is calcareous and forms a very large coral, although a large part of it has evidently been broken off. Its longitudinal diameter is 170mm., its breadth 140mm., and its height 90mm.

Remarks.—The present form agrees so very nearly with *Mich. glomerata* of M'Coy, that we barely think it advisable to separate it entirely from M'Coy's species. Yet there are some differences, which must not be overlooked. These consist in the tabulæ being nearly straight and considerably more numerous, characters which may no doubt have partly depended upon the circumstances under which the animals lived, but which yet constitute differences of some importance. Thus we have preferred to introduce the present form under the designation of *Mich. cf. glomerata*, M'Coy.

From the species previously described in this work, chiefly from *Mich. indica*, W. & W., it differs by its considerably smaller calices.

Family: *MONTICULIPORIDÆ.*

The family which has given us the greatest trouble in working out its affinities and its internal structure is that of the *Monticuliporidæ*, not only because there had to be taken into consideration two opposite opinions of long standing, one, supported by Lindström and Rominger, regarding these fossils as *Bryozoa*, and another, supported strongly by Nicholson, taking them to be corals; but also, because the family as circumscribed by Nicholson could not be retained as made to include forms of *Alcyonaria* as well as those belonging to the *Hexacoralla*.

The first point is therefore to show the affinity of the *Monticuliporidæ* to the corals, in opposition to the view which considers them as *Bryozoa*. In our endea-

vours to decide this question great difficulties were encountered on account of the fact that no decisive characters have so far been made out, by which the stony abodes of certain corals and those of the *Bryozoa cyclostomata* could be distinguished. Both consist of minute cells, more or less tubular, often with horizontal partitions or tabulæ; and even organs comparable externally to radial septa are not entirely absent in some *Bryozoa;* from all which it appears that in fossil forms neither the general habitus of the colonies nor the internal characters of the single cells can be made use of for the distinction of the *Monticuliporidæ* and the *Bryozoa.* Yet after careful studies we detected certain distinctive characters in the modes of propagation which are so radically different as to affect the shape and structure of the colonies; the structure of the walls of the cells is also different in the *Monticuliporidæ* and in the *Bryozoa.*

In all these considerations, however, we must exclude the genus *Heteropora,* Blv. In its structure, it cannot be denied, this genus exhibits a certain affinity to the *Monticuliporidæ,* but there are also so many discrepancies that its real relations must probably be looked for in other quarters. We were ourselves not in a position to make observations on recent species of the genus, but the descriptions given by Nicholson are so excellent that barely any new facts can be brought to light. As far as can be judged from Nicholson's drawings, the propagation in *Heteropora* is exactly like that prevailing in *Monticulipora* or *Favosites,* whereby a central and a peripheral zone can be distinguished in the colonies of *Heteropora* as in *Favosites.* Mural pores are very numerous, and though Mr. Nicholson thinks them to be different from the mural pores of the *Favositidæ* by having proper walls, yet we cannot but record the fact, that we have repeatedly observed distinct walls surrounding the mural pores in true *Favositidæ,* and that it appears to be only a matter of exceptional preservation whether such walls can be distinguished or not. In the recent form of *Heteropora* studied by Mr. Nicholson, tabulæ occur only sparingly in the cells properly speaking, and are entirely absent in the interstitial tubes, whilst in fossil forms tabulæ appear in numbers in all the tubes of which the colony is composed; as an instance of this the figure of *Heterop. pustulosa,* Mich., in Zittel's Handbook Vol. I p. 611, may be compared. Lastly there occur in *Heteropora* numerous septal spines which are comparable to similar organs that very commonly occur among the *Favositidæ.* After all these facts we perfectly concur with Mr. Nicholson in his final opinion "that the pore-canals, septal spines and tabulæ, which are now known to exist in some species of *Heteropora,* are, at any rate, as reconcilable with its reference to the *Cœlenterata* as to the *Polyzoa.*" We may perhaps add that the modes of propagation observable in *Heteropora* are more in favour of placing the genus with the *Cœlenterata* than with any other group of animals. So long, however, as the animals inhabiting the colonies of *Heteropora* are not known, it is more or less useless to speculate on the systematic position of these objects. It may suffice to have proved that the systematic position of *Heteropora* is by no means certain, and as *Heteropora* is precisely the only connecting link

between the *Bryozoa* and the *Monticuliporidæ* such a demonstration goes already far towards elucidating the systematic position of the latter. If *Heteropora*, from a careful study of its animals, should ever be proved to be a *Bryozoon*, then also the *Favositidæ* would have to be removed to the *Bryozoa*, and Dollfuss's views in the matter would be perfectly justified. The relation of *Favosites* to *Alveopora*, *Favositipora*, and the like would, however, then remain an unsolved riddle. As the matter now stands, we may be perfectly justified if we exclude the genus *Heteropora* altogether.

If we turn now to the modes of propagation occurring in different groups of animals, we find, that in the *Bryozoa* there is only one such mode observable, and that is gemmation. In the corals, on the contrary, two such modes have been long since made known—*fissiparity* and *gemmation*. Whilst however in the *Bryozoa* gemmation takes place only in a single manner, by protruding one of the walls of the mother-cell and afterwards partitioning off the protruded part, there are many different ways in which gemmation has been observed to occur in corals. With regard to the gemmation of the *Bryozoa* very excellent observations have been published by Barrois (Recherches sur l'embryologie des Bryosoaires. Lille. 1877), Nitsche, Claparède, etc:; the mode of gemmation in the corals on the other hand has been studied in detail by Koch, whose chief work on the subject has been published in the Palæontographica (III Ser., Vol. V).

The difference between the animals inhabiting the colonies of *Bryozoa* and those that build up the colonies of corals are extremely striking in many respects, and must find their expression also in the mode in which the colonies are built up. The animals of the *Bryozoa* are in the first place much less long-lived than those of the corals, as they show, for by far the longest part of their existence, a so-called latent vitality. Each animal of a colony of Bryozoans produces one or two gems, only exceptionally more, all nearly simultaneously, and mostly whilst it is yet in a rather juvenile state, after which it stops its functions in this direction. The animal of a colony of corals never stops producing gems but develops them at all times of its life and at different levels. This difference alone is the cause of a quite different growth of the colonies of the two classes of animals. Whilst in the *Bryozoa* gems are produced only in the peripheral parts of the colony, augmentation only occurs at the margin of the whole colony, as for instance in *Brenicea*, or in arborescent forms only at the apex of the branches, as in *Entalophora*, in the corals gems are produced all over the colony, in great numbers if the animals are well off, well fed, etc., and in smaller numbers if the contrary is the case. This circumstance then accounts for the very striking contrast existing in the outward aspect of corals and *Bryozoa*. Whilst in the corals everywhere small calices are intermingled with larger ones, in the true *Bryozoa* (we do not speak here of *Heteropora*) the smaller cells are to be found only in the peripheral parts of the colony, the cells elsewhere being all of the same size. The internal structure as well becomes very different, as is chiefly

apparent in the arborescent forms, a mode of growth which is also most generally affected by the *Monticuliporidæ*. If we make a longitudinal section through a branch of an arborescent colony of a *Bryozoon* we find that all the cells take their origin in a most regular manner at the imaginary axis, slowly ascending and bending sideways to reach the surface of the branch. There is no splitting of these cells; the gemmation is restricted to the vicinity of the imaginary axis, and thus the distinction of a central and a peripheral part of the branch, as can always be made in the branches of *Monticuliporidæ*, is impossible. In forms like *Cellepora* in which the colonies form a mere agglomeration of accumulated cells, the mother-cells, from which the new ones have taken their origin, can always very distinctly be made out; and it must not be forgotten that for the propagation of vitality there must remain free communication between the young feeding animals and the old ones, for the passage of the nutritive fluid, so that more or less large pores must remain open in the walls of all the single cells by which the animals communicate with each other.

Having thus in a general way indicated the mode of propagation prevailing in the *Bryozoa* on the one hand, and in the corals on the other, we may now turn more in detail to that of the *Bryozoa* and of the *Monticuliporidæ*.

After Mr. Smith's discovery of a kind of dimorphism or metamorphosis occurring in the colonies of *Bryozoa*, whereby such a colony in the young state would seem to belong to another genus from that presented in its more advanced state of growth, the question of the propagation or gemmation in the *Bryozoa* was placed in a new light. The endeavour on the part of Mr. Barrois to treat this subject more in detail in his very important work on the Embryology of the Bryozoa must be thankfully acknowledged. The point which is of the utmost value to us is that Mr. Barrois demonstrated beyond any doubt that in the *Bryozoa* the mode of gemmation in all cases remains the same. He says in this respect (p. 77 of his work): "J'ai toujours observé comme on peut le voir dans le bourgeonnement de la loge primitive, que les nouvelles loges se formaient par simple renflement, suivie du cloisonnement, de la loge précédente; la chose m'a paru se passer de même pour tous les bourgeonnements successifs aussi bien chez les *Phalangelles* que chez les *Crisies* et tous les autres cas que j'ai pu observer." This is how propagation takes place in the *Cyclostomata*, that group of *Bryozoa* which can alone be considered as perhaps allied to the *Monticuliporidæ*.

Somewhat different is the mode of propagation in the *Chilostomata*. With regard to this group very exact observations have been made on *Flustra membranacea*, Linn., by Dr. Nitsche. In the beginning, so long as the colony is still very young, the propagation resembles to a certain extent that of the *Cyclostomata*, but in old colonies, the separate animals are prolonged in creeping radial tubes, which sometimes bifurcate, and in which, at the proximal end, parts are constantly chambered off as soon as they have reached the normal length of one of the animals. These chambers are the gems in which the animals are slowly developed. In the meantime the tube constantly augments in length at the distal end. This mode of

gemmation is the least important for us, as it has been observed up to the present in the *Chilostomata* only; it appears, however, more or less as a modification of that occurring in the *Cyclostomata*. Another mode of gemmation, almost entirely in accordance with that occurring in *Cyclostomata*, has been described by Claparède in several arborescent forms of *Chilostomata*. From all that we can gather with regard to the gemmation of recent *Bryozoa* it appears that, besides having the gemmation restricted to a very short period in the single animal's life, the production of gems is also restricted to one side of the animal only. It is always on the side opposite the aperture of the cell. This can very easily be made out in the *Chilostomata*, where the aperture is always more or less lateral; but also in the *Cyclostomata*, where the aperture is terminal, the apex always bends to one side, opposite to the side on which gems are produced. We will call the gem-producing side the dorsal one. In creeping colonies this dorsal side is turned downwards, in arborescent forms it is turned inwards, towards the axis of the stem. If thus a creeping colony changes into an arborescent one, the animals must turn round to a certain extent, to bring their dorsal sides into a fitting position; but that is all the change that takes place in such a case.

In the corals on the contrary, gemmation takes place indiscriminately on all sides of the animal, and therefore no linear descent of the respective animals is observable.

In the *Monticuliporidæ* propagation occurs in a way which deviates very far from the modes described in the *Bryozoa*. As in corals two essentially different modes of propagation are observable: gemmation and fissiparity. The first of these is the more common one and therefore we shall consider it first in the *Monticuliporidæ*. If we turn to Prof. Koch's extremely important paper on the propagation of corals, we find that he does not retain the old opinion as to the essential difference between fissiparity and gemmation, and from a biological point of view such a distinction may indeed not be entirely justifiable, but from a practical point of view it appears to us as of great importance. Mr. Koch distinguishes six different modes of gemmation, two of which would, according to former views, correspond to fissiparity, whilst the other four would represent gemmation in the more restricted sense. We have now observed that the modes of gemmation in the more restricted sense are characteristic of single groups or even large divisions of the *Anthozoa*, whilst fissiparity is not restricted to a single group or class, but occurs off and on in all forms along with one or the other form of gemmation, though again on the other hand, fissiparity becomes the rule in certain large groups of corals nearly to the exclusion of gemmation. From these considerations it seems desirable to retain the distinction between fissiparity and gemmation, and thus we shall treat of each separately.

The four modes of gemmation are classed by Koch in the following manner:—

A—Internal gemmation:—

a, Tabular gemmation: the young corallites are produced by means of singularly transformed tabulæ.

This mode of gemmation chiefly occurs in the *Rugosa* or *Tetracoralla.*

B—External gemmation :—

a, Intermural gemmation : the young corallites are produced by the splitting of the primary mural plate (or primordial wall) of two or more adjoining corallites.

b, Cœnenchymal gemmation : young corallites are produced by the fusion of several interstitial tubes.

c, Stolonal gemmation : young corallites are produced by the budding of one of the stolones.

The last of these modes of gemmation is entirely restricted to the *Alcyonaria ;* the second seems chiefly so, whilst the first has been observed up to the present in *Favositidæ* and some *Hexacoralla.*

If we regard the *Monticuliporidæ* as a whole, as they have been circumscribed by Nicholson, we find that in the forms thus comprised under the name two of the above distinguished modes of gemmation are observable—the intermural and the cœnenchymal gemmations. According to the occurrence of the two modes of gemmation two different groups of forms can be distinguished within Nicholson's *Monticuliporidæ*, of one of which the genus *Monticulipora*, whilst of the other the genus *Fistulipora*, may be considered as the types. We take the two groups as forming two different families, for the one of which we retain the name of *Monticuliporidæ*, whilst for the other we create the name of *Fistuliporidæ*. The latter family must, however, at the same time be removed to the *Alcyonaria*, a mode of proceeding which will be justified later on.

In the *Monticuliporidæ* in this restricted sense, there exists only one mode of gemmation and this is the intermural one, which is chiefly characterised by the circumstance that the young animal formed by gemmation has no part in common with the mother animal, so that it is impossible to say from which of the surrounding animals the new one took its origin. It looks as if the new animal were only filling up a void space between several old animals.

The gemmation can very easily be made out on tangential sections of the fossils belonging to the family. It needs only a glance at our Pl. CX, figs. 1*c* and 3*c*, or Pl. CXIV, fig. 2*c*, to become convinced of this. Generally gems are developed where three or more corallites come into contact, but also at other places they are sometimes to be found.

Gemmation very generally commences with a thickening of the primary mural plate or primordial wall. These thickenings can easily be recognised in this connection when they occur where several corallites meet; but when they occur at intervals in the extension of the primary mural plates, as is not rarely the case, then their interpretation has caused much difficulty. These thickenings have then been called "Wandstränge" (mural strings) by Dybowsky, and have partly been considered as the so-called spiniform corallites by Nicholson. Our figures Pl. CX, figs. 1*c* and 3*c*, are chiefly instructive in this respect ; it may be useful at the same time to compare

Pl. CXIII, figs. 1*e*, 1*f*, 3 and 4. These thickenings are of very varying extent. Sometimes they stretch over long distances before the formation of a new corallite actually takes place, sometimes the thickening occurs only just before it makes its appearance. Even in one and the same corallum differences in this respect can be observed at different levels within the colonies.

After this thickening has been completed then the primary mural plate of the new individual thus developed begins to be formed. In the middle of the originally dark thickening, light coloured wall-substance appears, surrounded by dark lines, indicating the primordial wall of the new individual. In this state no hollow for the reception of the animal as yet exists. This state of development is not often to be observed, as it lasts only for a short interval. Nevertheless it is occasionally exhibited in our figures: for instance in Pl. CX, fig. 3*c*, such a gem can be observed, of a triangular shape, bearing at its corners already again thickenings, the commencement of new gems. Also in Pl. CXIV, fig. 2*c*, this state of development can be observed.

The third and last state of development is reached when the light-coloured wall-substance in the middle of the gem becomes perforated, thus forming the hollow for the reception of the animal. This state of development can very easily be seen in every tangential section, but caution is needed not to mistake it for that produced by fissiparity, which is not very different in appearance. With some practice, however, it will not be difficult to distinguish between the two modes of propagation. Very frequently the two occur together in one and the same section.

It is rather rare that all the three stages in the development of the genus can be distinguished, as in very many cases the primordial wall has either been obliterated or otherwise altered by the process of fossilisation. Often mineral matter has been deposited on it, and then often the primordial walls appear as if resolved into a string of beads, and the thickenings which afterwards give rise to the formation of gems cannot well be made out (compare in this respect Pl. CX, fig. 1*c*, Pl. CIX, fig. 2*a*, &c.). In most cases, however, the first and the last stage of development can be well distinguished. The difficulty of observation of the intermediate state probably caused Mr. Nicholson to mistake such half-developed gems as singularly transformed individuals, for which he introduced the name of spiniform corallites.

The intermural gemmation cannot be so clearly discerned in longitudinal sections. The cause of this may be found in the circumstance that in such sections more than two individuals can never be seen in close contact. Nevertheless in such sections also the process of gemmation can be well made out, and it needs only a look at Pl. CX, fig. 1*d*, to become convinced of this. The primary mural plate, here indicated by a dark line, ascends, and suddenly divides in two, enclosing in the acute angle thus formed light coloured wall-substance. Higher up the hollow is formed in which the new animal resided.

A few schematic figures will show the process of gemmation more clearly than any description can; to this end we present here some such figures:—

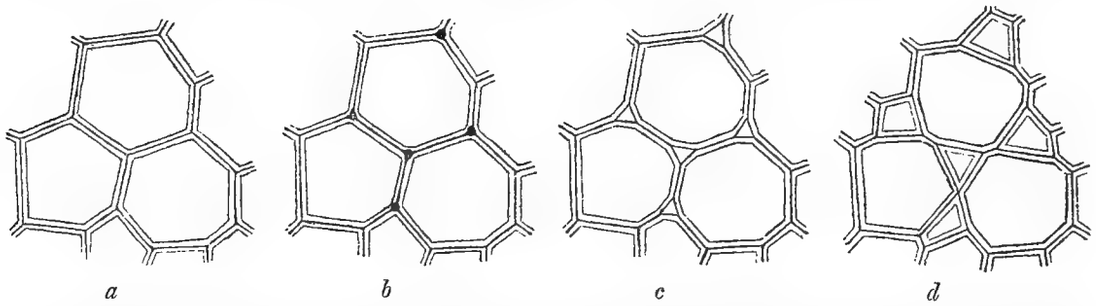


Fig. 28. Schematic figures of the intermural gemmation of a *Monticuliporid* as seen in tangential sections: *a*, three corallites without gems; *b*, the same with the commencement of gemmation, showing thickenings of the primordial walls where three corallites meet; *c*, the primordial walls of the gems are already formed, but no hollows for the reception of the animals are as yet present; *d*, the gems fully developed, but as yet of smaller size than the mother-animals.

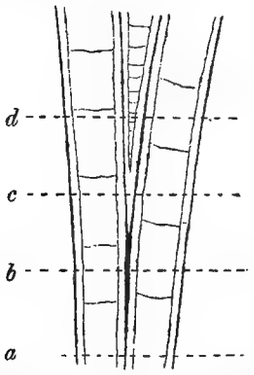


Fig. 29. Schematic figure showing the intermural gemmation of a *Monticuliporid* as seen in a longitudinal section: the dotted lines *a*, *b*, *c*, *d* corresponding to the tangential sections represented in fig. 28, with the sole difference that in the present figure only two corallites with only one gem between them is represented.

This gemmation, as now described in detail, is certainly very far different from the mode of gemmation occurring in *Bryozoa*, as described above. The most radical difference always consists in the circumstance that in the *Bryozoa* the fully developed animals do not produce gems, but only the quite young ones, which are themselves still more or less in the state of buds. After this the next important difference is, that in *Bryozoa* the mother-animal, from which the new one took its origin, can always be made out, whilst this is not the case in the *Monticuliporæ*.

On the other hand the gemmation which we have just described in detail in the *Monticuliporidæ*, is absolutely identical with that occurring in the *Favositidæ*, and Koch's figures of the gemmation of *Favosites gothlandica*, Gdf., might almost as well be taken from specimens of *Monticulipora*, the only difference being, that the thickenings of the primary mural plate inaugurating the formation of gems is more frequent in the *Monticuliporidæ* than in *Favosites*, whereby results the fact that the corallites at the surface of the colonies are of more unequal size in the *Monticuliporidæ* than in the *Favositidæ*.

Another mode of propagation is, as has been stated above, that which is brought about by fissiparity. Fissiparity, however, is a mode of propagation which points to such a low organisation of the animals in which it occurs, that, when we are able

to prove its occurrence in the *Monticuliporidæ*, it appears absolutely impossible to unite them with the *Bryozoa*.

As a fact, fissiparity is not at all of rare occurrence in the *Monticuliporidæ*, and there are numbers of figures in the works of Nicholson and Dybowsky which show very distinctly this mode of propagation. It needs only a reference to Pl. I, figs. 1—3 of Dybowsky, or Pl. I, figs. 4*c* 4*d*, Pl. III, figs. 3*e* 3*f*, Pl. VI, figs. 1*f* 1*g*, and to the woodcuts on page 171, fig. 32 *C*, or page 173, fig. 33 *B*, of Nicholson's work on the *Monticuliporidæ* to confirm this assertion. Fissiparity can very easily be distinguished from gemmation by the circumstance that the internal space of the new animal forms part of the internal space of the mother-animal. It can more easily be distinguished in longitudinal than in tangential sections. In longitudinal sections this mode of propagation can easily be recognised, inasmuch as in this case within the space of one of the corallites, which is well characterised by the two longitudinal walls stretching along, between which the tabulæ are spread out—a new longitudinal wall suddenly appears, dividing the internal room of the old corallite into two, and thus giving rise to two new corallites. Generally such a new longitudinal wall begins at one of the tabulæ, and to understand this, it may be well to accept the opinion, that only that part of the corallite above the last tabula was occupied by the living animal, whilst all below was dead.

In tangential sections fissiparity can less easily be distinguished. One can, however, often observe one corner of a polygonal corallite partitioned off by an oblique wall, whereby a new animal of more or less triangular shape is formed, which slowly increases in size and assumes by degrees a polygonal outline. This view, in combination with the one represented by the longitudinal section gives a fair idea of the manner in which fissiparity takes place; the animal is literally split in two by a wall, which stretches from one side of its body-cavity to the other. The radical difference of this mode of propagation from the intermural gemmation described above is obvious.

Also in this case schematic figures will perhaps give a more clear idea of the process than description can do; we therefore give some figures representing fissiparity.

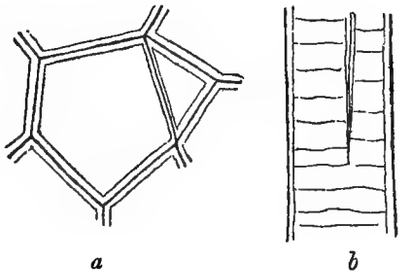


Fig. 30. Schematic figures representing fissiparity as occurring in the *Monticuliporids*: *a*, transverse section of a corallite bearing at its side a young animal produced by fissiparity; *b*, longitudinal section of a corallite showing the splitting into two of the mother-animal.

It cannot be asserted that something like fissiparity has never been observed in *Bryozoa*, whilst it is of very general occurrence in corals. Formerly the opinion was

entertained that *Chætetes* increased solely by fissiparity, whilst in *Monticulipora* gemmation alone should occur. As to *Chætetes* we cannot express any opinion, as we had no materials for observation, but with regard to *Monticulipora* already Nicholson expresses strong doubts as to gemmation being the sole mode of increase. The difficulty was always that one was not inclined to admit the two modes of propagation as occurring in one and the same form; but in the course of our investigations we so often found that fissiparity existed together with gemmation in one and the same colony of corals that we must consider fissiparity as a perfectly independent mode of propagation, which occurs off and on throughout the whole class, whilst the special mode of gemmation is characteristic of single groups.

If thus the mode of increase of the colonies of the *Monticuliporæ* seems not to be in favour of the supposition of these organisms being *Bryozoa*, there are yet other points which also oppose such a supposition. One of these is the structure of the walls in the *Monticuliporæ* and in the *Bryozoa*. There are many forms of *Bryozoa* which deposit carbonate of lime in the ectocyst of their body more or less abundantly. This deposition takes place in the median layer of the ectocyst only, whilst the outer and inner layers remain of a horny nature, which probably is the cause that in thin sections the calcareous walls of the single individuals appear separated from each other by dark lines. If we now consider more in detail the structure of the calcareous substance of which the walls of the cells are built, we find that it is composed of very thin fibres placed vertically to the surfaces of the wall, so that in sections cutting the single cells transversely, a concentric arrangement of the fibres can never be observed. These fibres leave interstices between them at intervals producing numerous capillary tubes, by which the walls of the *Bryozoa* seem always to be pierced in great numbers, if otherwise sufficiently well preserved. Every work on recent or fossil *Bryozoa* shows this. Either these capillary tubes occur all over the surface of the walls or they are restricted to certain places, as in the *Fenestellidæ*, to the so-called basal plate, or in the *Petaloporidæ*, to the thickened wall-substance between the single pores.

An exception to the rule seems to be made by *Heterodictya*, Nich., where the walls seem to be built of parallel calcareous plates, according to Mr. Nicholson's drawings.

Of all this there is not a trace in the *Monticuliporidæ*. The chief element of the walls of the single individuals is here the primary mural plate, or primordial wall as it is called by Nicholson. This primordial wall appears in most cases as a dark line hemmed in on both sides by light coloured masses of sclerenchyma, which latter in itself again is made up of oblique, symmetrically arranged fibres. In the axial parts of the colony, the walls that separate the single individuals consist generally solely of this primary mural plate. Nicholson thinks that this primordial wall must be made up of two thin laminæ, each of which would belong to a different individual; but though we took great trouble, had excellently preserved preparations at our disposal, and could thus employ very high magnifying powers, we were

never able actually to distinguish such a duplex structure of the primordial wall, and we are forced to the conclusion that such does not exist, and that in the axial parts of the colonies the primordial wall is in common to two adjoining individuals.

The preservation of this primordial wall is extremely uncertain, and this great variability in the preservation often causes very different aspects even at different places of one and the same preparation. In the normal state, as has been mentioned above, it appears as of a dark compact substance, and forms a dark boundary line between the different individuals. In other cases it is replaced by light coloured calcareous matter or resolved into a series of dark spots, as for instance in *Orbipora distincta*, Eichw., as figured by Dybowsky, Pl. II, fig. 10. These different modes of preservation must, however, not be mistaken as radically different things.

This primordial wall is hemmed in on both sides, as has been stated above, by secondary thickenings which may appear either at a rather early state of development of the single individuals or only later on, as is chiefly the case in *Dianulites petropolitanus*, Eichw., and similar forms, where the thickenings appear only quite at the peripheral parts of the colony and never become very thick. These secondary thickenings very easily fall off, and are the cause that natural fractures always take place along the primary mural plate. This latter sticks to one side of the fracture, whilst the secondary thickening on the fractured side of the primordial wall adheres to the other side of the fracture, which causes the appearance as if the primordial wall had split in two. In the axial zone of the colonies the fractures also take place along the primordial walls, but the latter adheres entirely to one side of the fracture, whilst the other side exposes the smooth internal cast of the adjoining individual, which by the extreme thinness of the primordial wall, and the barely perceptible difference which thus exists between the two sides of the fracture, can only with difficulty be recognised as such.

The secondary thickenings are always composed of successive reversed conical layers of sclerenchyma, as has been observed already by Nicholson. In tangential sections the successive layers thus appear as concentric rings surrounding the visceral cavities of the single corallites. But also here again preservation is of the utmost influence on the appearance of preparations, and it is very easy to fall into mistakes on this account. Very often, chiefly in cases where the primary mural plate is not well preserved or has entirely disappeared, these rings, formed by the secondary thickening of the wall, are only partly visible, and then mostly only as a zone surrounding the visceral cavity, and being of very variable thickness in different specimens, can be clearly made out. This zone is then very distinctly limited off, and it seems to us, that in species like *Monticulipora ramosa*, E. and H., or *Mont. rugosa*, E. and H., &c., this zone or the outer limit of it has been mistaken by Nicholson to be the primary wall. In all cases where such 'marginal rings' have been figured by Nicholson in the tangential sections, the longitudinal sections of the same species show nothing of such an organ, but they most distinctly exhibit the primordial wall along the *middle line* between two adjoining corallites: an

unmistakable indication that the appearance of marginal rings is caused solely by the mode of preservation.

The reversed conical layers of which the secondary thickenings of the walls consist are again themselves composed of little fibres, which extend parallel to the layers.

The difference in the wall-structure of *Monticulipora* and the *Bryozoa* is thus obvious. It results from the mode of growth prevailing in the corals on the one hand and the *Bryozoa* on the other. The *Bryozoon* as an animal of rather high organization is very short-lived; its abode is completed as soon as the gem has attained fullsize; the animal is only for a very short time a feeder, after which it assumes a latent vitality in which its chief function is restricted to the thickening of the walls of its lodge, and thus strengthening the stony parts of the whole colony. The size of the lodge is fixed and cannot be extended beyond the length of the animal. If tabulæ really do occur in such forms, they are not a sign of progressing growth of the zooid; the probable explanation is that in the retrograde metamorphosis to which the zooids are subject, a shrinking of the animal occurs, and in this shrinking process the animal deposits from time to time diaphragms behind its ever contracting body. Just the reverse is the case in the corals.

The animals of a colony of corals undergo constantly a certain process of renovation. The animal deposits large masses of sclerenchyma behind itself and thus slowly ascends within its tube, sometimes chambering off the dead and useless parts of the corallum by diaphragms or tabulæ. The animals are all self-feeding, performing all their vital functions during their whole lifetime, at the same time constantly producing new gems. The structure of the walls is in accordance with these peculiarities. The reversedly conical layers of sclerenchyma by which the wall of the *Monticuliporæ* is built up indicate the ascending movement of the animal within its tube.

The circumstance, that the greater part of the animals of a colony of *Bryozoa* is in a state of latent life, the functions of taking and digesting food being performed only by a few animals at the top of the branches in arborescent colonies, brings with it the other peculiarity, that all the animals of a colony are in intimate connection and communication together. This communication seems to be brought about partly by the capillary tubes mentioned above; for the most part, however, it is effected by large openings in the walls of the lodges, by which a free communication of all the animals of a colony is established. If the *Monticuliporæ* were *Bryozoa* such openings must exist and they must have been observed in some case or other, but nothing of the kind has ever been detected.

From all this it appears highly probable that the *Monticuliporæ* are no *Bryozoa*, and as they show the greatest affinity to the *Favositidæ* it is very probable that they must be considered as corals and placed among the *Hexacoralla*.

In opposition to all this stand Mr. Lindström's observations, which affirm a metamorphosis in the *Monticuliporæ* similar to that which has been observed by

Smith in living *Bryozoa*. Two cases of metamorphosis are treated more in detail, first, that of *Monticulipora ostiolata*, of which he states, that it begins its career as a *Discoporella*, changes next into a *Fistulipora*, then into a *Thecostegites*, to become at last a true *Monticulipora;* second, that of *Monticulipora* (*Dianulites*) *petropolitana*, which is stated to begin as a *Ceramopora*, and even during its growth is off and on again changed into that genus, a case of atavism.

The latter case has been treated of already by Nicholson in his book on the *Monticuliporidæ*, and he adduces many reasons why such a change should be considered as very improbable. To these we may add the circumstance that *Dianulites petropolitanus* shows unmistakably an intermural gemmation, a character which is absolutely prohibitory to a *Bryozoan* nature of the fossil. Dybowsky remarks, that the species here adduced sometimes appears incrustating, and the same can be said of *Ceramopora*. It might thus well be the case that the specimens examined by Mr. Lindström showed the two forms, one incrustating the other.

The first case is, according to our investigations, still far more extraordinary. We must confess that, among the materials at our disposal, we were never able to detect a similar change from one form into the other, though incrustation of very different things, one over the other, are of very general occurrence. There is no doubt that Mr. Lindström was able to state similar superpositions of one form over the other, but whether they also were not incrustations we are not able to decide.

There are many reasons which make it probable, that also in Mr. Lindström's specimens only superposition of different forms was in reality present. That Mr. Lindström has been forced to compare the quite young state of *Monticulipora* to *Discoporella* is not a very surprising fact. *Monticulipora* as well as *Fistulipora*, *Thecostegites*, and a great many *Bryozoa* must in their quite young state show so much similarity to each other that a distinction will in reality be very difficult. Each of these forms is oviparous, and the first lodge developes out of the egg. Though this process is very different in corals and in *Bryozoa*, yet in fossil forms certainly this difference can mostly not be made out. From this first lodge the others take their origin by gemmation, but the colony must attain a certain size before the differences of gemmation as existing in corals and in *Bryozoa* can be made out in fossil forms. Thus the exact determination of quite young specimens will always remain doubtful, and mistakes, taking *Bryozoa* for corals, and corals for *Bryozoa*, will be unavoidable.

In more advanced stages of growth, however, an exact determination can always be made, and then also the observations of Mr. Lindström point rather to incrustation than to metamorphosis. If we take only the mode of gemmation into consideration, we find that *Fistulipora* has a cœnenchymal gemmation, *Thecostegites* a stolonal gemmation, and *Monticulipora* an intermural gemmation. There are now two facts which must here be taken into consideration; first, that in the *Bryozoa* the mode of gemmation is always the same, and shows much less variation than in

corals, and that in corals also only one mode of gemmation occurs within one and the same genus or even the same family. According to the mode of gemmation *Thecostegites* and *Fistulipora* belong to the *Alcyonaria*, and *Monticulipora* to the *Hexacoralla*; and it is almost impossible that one should change into the other. On the other hand, it is a fact that *Fistulipora minor*, which is quoted by Lindström as the *Fistulipora*-stage of a *Monticulipora*, is an incrustating species as stated by Mc'Coy, so is *Thecostegites* incrustating, as mentioned by Quenstedt in his Petrefactenkunde Deutschlands, Vol. VI, part 1, p. 121. That *Monticuliporæ* are often incrustating we can state from our own observations. How frequently incrustation occurs in general is shown by our own plates, where Pl. CIX, fig. 3*b*, Pl. CX, fig. 2*b c*, Pl. CXII, figs. 1, 3, & 5, and Pl. CXIV, fig. 2*d* & 3*b* shew such incrustations.

Thus, then, Mr. Lindström's observations cannot change our view that the *Monticuliporæ* are corals.

After having settled, as far as possible, the position of the family, at least as far as its relations to the corals in general are concerned, we can now turn to discuss the structural characters of the *Monticuliporidæ*. The discussion of this is for us comparatively easy, as in the excellent works of Nicholson and Dybowsky, the general features of the structure have been sufficiently treated, so that we are not obliged to repeat here all that has been said in those works. Nevertheless, we must treat some points more in detail, as in these, we regret to say, we are not quite in accordance with the views expressed by Nicholson.

Mr. Nicholson has expressed the opinion that all the *Monticuliporidæ* were dimorphic, and that they thus ought all to be considered as belonging to the *Alcyonaria*. Though there cannot be any doubt as to the fact that certain forms, which were formerly included by Nicholson in the family, and even some of those which he includes in the genus are in reality dimorphic, yet another part, and that the greater number of forms included in *Monticulipora*, are as certainly not dimorphic, and thus radically different from the first. The dimorphic forms are those which show a cœnenchyma intercalated between the corallites proper, composed of numerous interstitial distinctly tabulated tubes, which augment by fissiparity, whilst the large corrallites interspersed between them augment by cœnenchymal gemmation as defined above.

Mr. Nicholson may kindly excuse us when in this case we employ the term "cœnenchyma," to which he so strongly objects with regard to Dybowsky's work; but since such an excellent observer as Mr. Koch has also applied the expression in *Heliolites* and other true *Alcyonaria*, we may be allowed to employ it here for simplicity's sake. This group of forms is chiefly typified by the genus *Fistulipora*, Mc'Coy, and is very nearly related to *Heliolites*. Of the species described in Nicholson's large book on the genus *Monticulipora*: *Diplotrypa whiteavesii* Nich., *Diplotr. calycula* James, *Prasopora selwynii* Nich., *Prasopora newberryi* Nich., *Pras. grayæ* Nich. and Eth., and *Geronopora cincinnatiensis* James, which all show, according to Nicholson's drawings, a cœnenchymal gemmation, belong also to this group of forms. We shall

have occasion in the course of this work to unite all these forms under a proper family which will bear the name of *Fistuliporidæ*.

The forms, however, which have no cœnenchymal gemmation, are not dimorphic, as we shall prove presently. It would be strange if an observer of such excellent qualities as Mr. Nicholson should have overlooked all the facts which speak against a dimorphism, and accordingly we find also in his book on page 50 the following passage: "At the same time, there are forms, otherwise quite resembling the dimorphic species, in which all the corallites of the colony are apparently similar in their internal structure and approximately equal in size, so that we are not able to assert positively that the corallum in *Monticulipora* invariably consisted of two different sets of tubes." The first character which induced Mr. Nicholson to accept the idea of two different sets of corallites in the *Monticuliporidæ* is the existence of differently sized tubes, opening on the surface of the corallum, which is very striking even to the casual observer.

It cannot, however, be denied that this character is decidedly not restricted to the *Monticuliporidæ*. In the *Favositidæ* it is nearly just as striking, and has caused Mr. Moseley to consider even these as belonging to the *Alcyonaria*. In the case of the *Favositidæ* the question seems now settled, after the detection of the near relation that exists between *Favosites* and some *Hexacoralla* of the family *Poritidæ;* and notwithstanding the different sizes of the corallites very often exhibited by *Favosites* and allied genera, these forms are now generally placed among the *Hexacoralla*. Thus also in the *Monticuliporidæ* the existence of differently sized corallites cannot be considered as a character that absolutely requires a systematic position for these forms, placing them in the *Alcyonaria*. It was chiefly Quenstedt, in his Petrefaktenkunde Deutschlands, who remonstrated most decidedly against laying too great a weight on the different sizes of the single corallites, and every observer who has studied *Monticuliporæ* in detail knows that different parts of one and the same colony may be absolutely different with regard to the corallites of which they are composed. Very often the central part of the colony shows corallites not very different in size, whilst in the peripheral parts large and small corallites are mixed together in the most irregular manner. Dybowsky has already made similar observations; he says of *Dianulites fastigiatus* on page 23 of his work: "Whilst in the middle of the colony the polygons corresponding to the transversely cut corallites are tolerably equal in size (Pl. I, fig. 1) the same polygons in a tangential section taken from the periphery of the colony are very unequally sized. Here numerous small polygons are irregularly interspersed between large ones (Pl. I, fig. 2)."

Though already from these considerations it becomes apparent how little systematic value can be put on the variable size of the single corallites, this fact becomes far more evident by the consideration of the mode in which the differently sized corallites originate. It needs only a look at any of Nicholson's, Dybowsky's, or our own drawings to see that the smaller corallites are young ones or gems which have

not yet attained their full development, and which have been produced by intermural gemmation. It is true that many of these never will attain the full size of the mother animals, as the corrallum generally stops growth at a certain size, and does not go on growing for ever, but it is only accidental that a certain number of the young individuals produced by gemmation cannot attain their full size, as all gems produced at earlier stages of growth do so, and only those produced just before the corallum has reached its final size, stop short before reaching their full development. As, however, the animals inhabiting the corals never stop producing gems, it is only natural that the gems produced just before the whole colony ceases augmenting in thickness or length appear in very different states of development on the surface of the corallum, some as small pores, but otherwise similar to the mother animals, and some even only as thickenings of the primordial wall,—a state which has been described above as inaugurating gemmation,—and projecting as little spines above the upper termination of that wall. Thus in all stages of growth large pores, small pores, and sometimes also little spines (spiniform corallites) will be observable on the surface of colonies of the *Monticuliporidæ*. There are however yet some observations to be made with regard to the frequency of gemmation. H. v. Heider has published in the Sitzungsberichte of the Academy of Sciences of Vienna (1881, Vol. 84, p. 636) notices regarding the gemmiferation of recent corals, and he remarks that the frequency of production of gems varies to a great extent with the outer circumstances under which a colony exists. If these are favourable and the single animals get plenty of food then gems are produced in endless numbers; but change the outward circumstances, let food become scarce, and so on, then the production of gems is greatly reduced. The same is observable in *Monticuliporidæ*, but here this is not without influence on the outward appearance of the colonies. If gemmiferation is reduced only for a short time to a certain extent, then the old gems, when no longer hampered by so many new intruders, grow astonishingly quick to the same size as the mother animals, and the surprising fact comes to light that the whole colony, or at least part of it, consists of cells, which are nearly all of about equal size. Such a fact was detected by Dybowsky, but was not rightly interpreted: he thinks of *Dianulites fastigiatus* that gemmation was going on in this species only in the peripheral parts, because only there the corallites are of markedly different size; but that the older parts of the colony also had been augmenting by gemmation is shown by Dybowsky's own drawings (Pl. I, fig. 3).

If thus the different size alone cannot constitute a radical difference between the several corallites composing the colony of a *Monticulipora*, the mostly observable deviating disposition of the tabulæ, as shown by Nicholson in so many forms, may perhaps constitute such a difference. With regard to the tabulæ an observation of H. v. Heider may perhaps also be of importance. He has shown that in *Cladocora* the number of septa within the calices varies greatly with the conditions under which the animals live. If the animals are well fed they produce more septa, than if the contrary is the case. May not then the same circumstance prevail with

regard to the tabulæ? In a great many longitudinal sections one observes that the tabulæ are of very unequal distribution within the tubes. Partly this might be attributed to the mode of preservation of the specimens, but partly the tabulæ seem to have been in reality of very unequal distribution. We may quote in this respect the figures given by Nicholson in his book on *Monticulipora*, page 112, fig. 18 D and E, page 114, fig. 19 B and D, Pl. VI, fig. 1*g*, and many others. It is true that mostly the newly produced gems are more closely tabulate than the older animals, but as also these vary during their lifetime in this respect, we need not be astonished that the young animals placed more near the surface of the colony, and probably more vigorous than the old animals, were more freely nourished, and thus were able to deposit tabulæ more frequently.

If thus one and the same animal during its lifetime can change from the widely tabulate form into the closely tabulate one, and *vice versa*, and if the closely tabulate form of the young animals occurs only in certain species, whilst in others, as is admitted by Nicholson, it is entirely absent, it appears barely possible that a difference in the tabulation should indicate a difference in organisation. It is quite incredible that one and the same animal should change during its lifetime from an antozooid into a siphonozooid, and from the latter again into an antozooid. It is likewise incredible that for some of the *Monticuliporidæ* the closely tabulate young individuals should have consisted of siphonozooids, and in others, where closely tabulate gems do not occur, the young individuals consisted solely of antozooids, whilst in all other respects the two forms may be so nearly related to each other that even a specific distinction may be difficult.

We can well admit, that the character of the young corallites being more closely tabulate than the old ones is of a certain importance, and we admit also that Mr. Nicholson very rightly has chosen this character for the establishment of sub-divisions within the genus *Monticulipora*, but what to us appears very doubtful is, whether the interpretation given by Nicholson to this fact is correct, and from the above considerations it follows, with much probability, that in reality no dimorphism of the animals inhabiting the colonies is indicated by this fact. The circumstance that this character can be made use of for the distinction of sub-divisions, proving most evidently that it is restricted to certain forms and is not of general occurrence, is one of the strongest proofs against the supposition that we have to deal here with radical structural differences in the one as well as in the other case. By the identical mode of gemmation all the true *Monticuliporidæ* are most intimately connected together; and Mr. Nicholson also advocates strongly that all these forms should remain united in one and the same genus, and that only sub-genera should be admitted. It is now utterly improbable that in one and the same genus dimorphic as well as not dimorphic forms should be contained, as this character just constitutes one of the chief differences between *Alcyonaria* and *Zoantharia*.

Besides the interstitial tubes, which, as we have endeavoured to demonstrate, are young gems in the state of progressive development, and the true corallites, there

have been distinguished by Nicholson in the *Monticuliporidæ*, yet another set of bodies which he calls "spiniform corallites." These are described as being in the beginning small, open, hollow tubes, which afterwards become filled up by sclerenchyma and then project on the surface of the corallum as little spines over the surrounding corallites. These organs are most distinctly developed in the genus *Dekayia*, E. and H., but are observable in a more or less strong degree in the greater part of *Monticuliporidæ*. Mr. Nicholson thinks them to be singularly modified corallites.

We may, in the first place, be allowed to state that these spiniform corallites appear to us to stand in a more or less close connection with the gemmation of the single colonies, but that rather different things have been placed by Nicholson under the name. In all the many cases in which we were able to observe the existence of spiniform corallites, we were convinced that these bodies do not commence their existence as little hollow tubes but are always in the beginning compact, and appear as thickening of the primary wall, generally at the places where several corallites meet together. A figure which is very instructive in this respect is that on Pl. CXII, fig. 2*d*., representing the central portion of a little stem of a Monticuliporoid coral. As is clear at a first glance on the structure of these corals, the central portion of the colony is the one which is first developed, and the cells in the centre show the most primitive development. Thus also with regard to the spiniform corallites; the central portions of the colony must show their first state of development, and if no hollows exist within them there, we can safely conclude that they are compact from the beginning. The figure quoted above shows us a number of these spiniform corallites within the central portion of the colony as compact dark spots without hollows in the middle. In the same figure, however, we see more towards the peripheral region of the colony, just where the transition between the central and peripheral regions takes place, these so-called spiniform correlates opening out and transforming themselves into little tubes. These again become more and more widened and at last become corallites of the common shape. From these observations it appears beyond doubt, that a great part of the so-called spiniform corallites are nothing but newly developed gems. As has been stated above, gemmation is always inaugurated by a thickening of the primary wall, and just this first stage is that which generally has been considered by Nicholson as the common form of the spiniform corallites. If a hollow was observed by Nicholson within these organs, then a somewhat more advanced state of gemmation was subject to his observation. The little spines, which very generally are observable on the surface of the colonies of *Monticuliporidæ* between the openings of the tubes, are nothing but the thickenings of the primary wall which, when the colony augments in size, afterwards change into gems and at last into corallites. If the surface is very well preserved, the primary wall projects as a high ridge in the middle between the tube openings, and in it the little spines are placed. Some of them are, however, always to be found in the state of opening out (see Pl. CXII, fig. 1*c*). The preservation of the specimens is not always such that the observations just

described could in every case easily be made. If the primary wall of the corallites is preserved by a white sparry matrix, and cannot be distinctly made out, as very often is the case, or if gemmation is so very frequent that the original thickenings of the primary wall can no longer be followed (see Pl. CXII, fig. 2*b*, or Pl. CXIII, fig. 2*b*.) then it is not easy to identify the spiniform corallites with gemmation; but if the process has once been studied in detail then also in these latter cases the real nature of the spiniform corallites can well be made out. One mode of preservation still needs special mention, and this is the one which has been figured by us Pl. CIX, fig. 2*a*. The entire primary wall seems here to be dissolved into a number of black spots, which appear exactly like spiniform corallites, only that they are a little less distinctly circumscribed. It seems to us that Mr. Nicholson has in some cases (for instance, in *Monticulip. tumida*, Phill.) taken this mode of preservation to represent spiniform corallites, which in reality is not the case. The real nature of these spots becomes clear from our figure Pl. CX, fig. 1*c*, where the upper right hand corner shows well-preserved primary mural plates between the single corallites, whilst the remainder of the figure shows the same primordial walls resolved into an irregular number of dark spots, the origin of which is evidently due to the deposit of mineral matter on the original primordial wall. Such mineral deposits cannot, however, be restricted solely to the vicinity of the primordial wall, but may appear anywhere within the substance of the wall and may then be very misleading as to the structure of this wall.

Mr. Dybowsky has fallen into the same error, in uniting the two different things—the spots caused by preservation and the real thickenings of the primordial wall inaugurating gemmation—under the same heading "Wandstränge." For instance, on his Pl. II, figs. 8*a*, 10, and 10*a* represent the first case, whilst figs. 9*a* and 9*b* represent the second case. There is again a mingling of different things in what he calls "Wandröhrchen:" what are represented on Pl. III of his work in figs. 3 and 3*a* are certainly young gems; whilst the "Wandröhrchen" in the genus *Trematopora* are something widely different, organs the nature of which we cannot guess at, as we have no materials for observation.

We thus think to have demonstrated that there was only one set of animals engaged in building up the colonies of the *Monticuliporidæ*, and that all the differences that have been observed can well be explained by the different states of development of the single individuals.

There remains now only to make some remarks about certain structural peculiarities of the *Monticuliporidæ* which have not been treated of so much in detail by Mr. Nicholson. The septa in the first place require some words. These have never been observed in the *Monticuliporidæ*, being here even more completely absent than in the *Favositidæ*. It is well known that in the latter family the septa are mostly replaced by irregular protuberances, consisting of thickened parts of sclerenchyma protruding irregularly into the visceral chamber. The same is, though rarely, the case in the *Monticuliporidæ*. Mr. Nicholson was acquainted with but few species

which showed a slight development of this character (for instance, *Mont. pavonica*, Orb.). By Dybowsky, however, there has been figured a species which has the character very strongly developed (*Orbipora panderi*, Dyb.), and we shall have to describe another species showing the same character in a rather strong degree.

The occurrence of such rudimentary septa, absolutely identical with what has been observed in the *Favositidæ*, is one proof more of the near relation that exists between the latter family and the *Monticuliporidæ*. Also in the *Chætetidæ* similar septa are of very general occurrence, and we perfectly concur with Mr. Nicholson when he considers the *Chætetidæ* as very nearly related to the *Monticuliporidæ* but forming properly a family by themselves.

A last peculiarity which is shared by the *Monticuliporidæ* and the *Favositidæ* is the frequent occurrence of cells that are apparently closed by something like an operculum. This organ has met with careful consideration on the part of Nicholson as well as of Lindström, and on the whole there can be but little added to what has been said on the point by these excellent observers. In the specimens at our disposal, however, the appearance as of an operculum is very frequently brought about by a secondary infiltration into the cells of carbonate of lime, which, as is well known, very often assumes a spheroidal shape, and no organic structure of any kind can be made out as closing the cells at their upper termination.

The *Monticuliporidæ*, in the sense we apply to the name, are of a rather wide geological range. They begin in the silurian epoch and have been so far traced up to the permian; it is, however, very probable that the family does not stop here but extends largely into mesozoic formations, as many of the species of *Heteropora* that have been described from such beds are in their structure absolutely indistinguishable from true *Monticuliporidæ*.

It is impossible now to have a clear view over all the forms that ought to be included in the family, as studies in this direction are still quite in their infancy. There are some genera which can be clearly recognised and will stand criticism, but of others this cannot be said, and thus it is extremely difficult to give an account of the forms which should be included in the family.

Three groups of forms can be recognised for the present: first, a group in which the walls of the single corallites are of a uniform thickness and the tabulæ simple; second, a group with walls of uniform thickness and vesicular tabulæ; and third, a group in which the walls of the corallites show periodical thickenings. These three groups can well be considered as forming sub-families, as each of them comprises several genera. For the first group the genus *Monticulipora* can be considered as typical, for the second the genus *Peronopora*, and for the third the genus *Stenopora*. Thus we get three sub-families: the *Monticuliporinæ*, the *Peronoporinæ*, and the *Stenoporinæ*.

For the distinction of genera within these sub-families several characters can be made use of, and these characters have been selected with great ability by Nicholson. These are: first, the condition of the young corallites, whether closely tabulate or

not; then the circumstance whether the state of thickening of the primordial wall, preceding gemmation, lasts for a certain time or is only quite transient; and lastly the mode of growth of the whole colonies.

The number of genera within the single sub-families is very small for the present, and we are not in a position to distribute all the different forms in proper genera. For the present the following genera may be retained:

I.—Sub-Family: *MONTICULIPORINÆ.*

1. Monticulipora, Orb., 1850: Prodr. Vol. I, p. 25. (Syn.: *Heterotrypa*, Nicholson, 1879, Pal. Tab. Cor. p. 293). The name *Heterotrypa* cannot, we regret to say, be retained, as just the forms comprised under this sub-division must get the name of *Monticulipora*, if the other sub-divisions are considered as distinct genera. The genus is characterized by the occurrence of numerous closely tabulate young corallites. The colonies are mostly arborescent. The geological range of the genus can for the present not even be guessed at. Species have been described up to the present from the silurian up to carboniferous strata.
2. Dianulites (Eichwald, 1829: Zool. special. Vol. I. p. 180), Dybowsky, 1877: Chætetid. d. ostbalt. Silurform. p. 14. (Syn.: *Diplotrypa*, Nicholson, 1879, Pal. Tab. Cor. p. 312). The name *Dianulites* must overrule that of *Diplotrypa*, even if one ignores Eichwald altogether and considers Dybowsky as the author of it. The genus is characterized by hemispherical or conical colonies, which bear on their under-surface a rather strong epitheca. The young corallites are either closely tabulate or not. The genus seems to be restricted to the silurian epoch. (That some forms placed in the genus *Diplotrypa* by Nicholson belong in reality to the *Fistuliporidæ* has been stated above.)
3. Monotrypa, Nicholson, 1879: Pal. Tab. Corals, p. 320. The genus has not been very fortunately circumscribed by Mr. Nicholson, and we rather think that those forms that bear an epitheca should be transferred to *Dianulites*, whilst those species that show thickened walls ought to be placed in *Orbipora*. The name of *Monotrypa* should be restricted to the forms without epitheca, in which the young individuals are never more closely tabulate than the rest, and the single corallites are of an angular transverse section.
4. Orbipora (Eichwald, 1829, Zoologia Specialis, Vol. I, p. 179), Dybowsky, 1877: Chætetid. d. ostbalt. Silur., p. 57. The name can well be made use of for those forms which are in all respects like *Monotrypa*, but in which the walls of the single corallites have become so much thickened that the transverse section of the corallites becomes oval or circular. Up to the present only silurian species of the genus have been described, to which must be added one species from the Salt-range.
5. Nicholsonia, Waagen and Wentzel, n. g. We create this genus to receive *Mont. pavonica* Orb., and other biserial species. A central zone, as it exists in other *Monticuliporidæ*, is here absent. The corallites start bi-laterally from a median line. Gemmation is not frequent, and thus there are also no "spiniform corallites." The typical species *Nicholsonia pavonica*, Orb. sp., is from the Cincinnati group of Ohio.
6. Dekayia, Edwards and Haime, 1851: Pol. foss. des Terr. Paléoz., p. 277. The genus is very nearly related to *Monotrypa*, and is chiefly distinct from it by the extreme development of the thickenings of the primordial wall which have received from Nicholson the name of spiniform corallites. The genus is restricted, as far as is known up to the present, to the silurian epoch.

II.—Sub-family: *PERONOPORINÆ.*

7. Peronopora, Nicholson, 1881: On the struct. and Aff. of Monticulipora, p. 215. This name has been created for forms which are composed of corallites with partly vesicular tabulæ and in which the young corallites are more closely tabulate and without vesicles. There are biserial as well as incrusting forms contained in the genus; but we are not sure whether a proper genus should not be created for the incrusting forms. Species of the genus have been up to the present solely observed in the Cincinnati group of Ohio.

III.—Sub-family: *STENOPORINÆ.*

8. Geinitzella, Waagen and Wentzel, n. gen. (Syn.: *Stenopora*, Geinitz., Schauroth, &c., *non* Lonsdale). The forms composing this genus are to a certain extent transitional between *Orbipora* and *Stenopora*. The periodical swellings of the walls of the corallites, characteristic of the genus *Stenopora*, are present but in a very reduced state, and differently developed in different specimens. The genus can be termed the representative of the *Stenoporæ* in the northern hemisphere. It has been observed up to the present only in permian strata.

9. Stenopora, Lonsdale, 1844: Appendix to Darwin's Volcanic Islands, p. 161; 1845, Strzelecki's Phys. Descr. of New South Wales, p. 262; (*non* Mc'Coy, Geinitz, Schauroth). Though it is stated by Nicholson, that *Stenopora* possesses mural pores, yet in the dozens of slides we prepared we were never able to detect such. It is thus very probable that Mr. Nicholson's indication is only an error of observation. If, however, the mural pores are absent, the genus cannot be placed otherwise than in the *Monticuliporidæ*. The periodical thickenings of the walls of the corallites are very conspicuous in this genus. The genus is restricted chiefly to the southern hemisphere and occurs there in carboniferous and permian strata.

These are the genera which can be distinguished for the present. Though we have no doubt that the number ought to be augmented considerably, yet this cannot be done for the moment. The microscopical studies of these forms, which have been so ably inaugurated by the magnificent works of Nicholson and Dybowsky, will have to advance much further before a more minute distinction of genera can be made out.

In the Salt-range the family is well represented, not so much by a great many different forms, as by very numerous and well preserved individuals. There occur two of the three sub-families, the *Monticuliporinæ* and the *Stenoporinæ;* each of which is represented by two genera, the first by *Monotrypa* and *Orbipora*, the second by *Geinitzella* and *Stenopora*.

Sub-family: *MONTICULIPORINÆ.*

Genus: MONOTRYPA, Nicholson.

The materials we possess of this genus are rather scanty and not in very excellent preservation. We therefore are, we regret to say, not in a position to give a more accurate description of the genus, nor to add anything new to the excellent

observations published by Mr. Nicholson on the subject. Only so much we must remark, that it appears impossible to retain the genus in the extension given to it by Nicholson, for thus circumscribed it appears to be identical with some previously described genera. The single character that the young corallites are not more closely tabulate than the adult ones is too wide for the characteristic of the genus: some other features must be taken into consideration to circumscribe easily recognisable generic groups. Thus it appears to us that the forms having a well developed epitheca, placed by Mr. Nicholson under the genus, should be rather placed with *Dianulites*, Eichw., instead of with *Monotrypa*, as just one of the most typical character of the former genus consists in the presence of an epitheca, which is otherwise of rather rare occurrence within the family.

As regards the name *Dianulites*, which has been rejected by Nicholson, we cannot help stating that according to all rules of nomenclature it must take precedence of the name *Heterotrypa*, as not only was it published fifty years previous to *Heterotrypa*, but also its accurate re-description by Dybowsky dates two years further back than the introduction of Nicholson's name.

Quite the same fate would, however, be in store for the name *Monotrypa*, if it were attempted to retain this genus in the extension given to it by Nicholson. Not only that a part of it is identical with *Dianulites*, but another much larger part coincides with the genus *Orbipora*, Eichw., as redescribed by Dybowsky two years previous to the creation of the name *Monotrypa*. It is the forms of *Monotrypa* with thickened walls of the single corallites that have been named *Orbipora* by Eichwald and Dybowsky.

If then we wish to retain the name *Monotrypa* at all, we must exclude from it the forms with thickened walls, and restrict the name to those forms which have the walls of the single corallites either not thickened at all or in which the thickening is not considerable, so as to exhibit in the transverse section the shape of the single corallites always somewhat polygonal, never quite oval or circular.

The number of species belonging to *Monotrypa* is thus very considerably reduced, and it appears barely possible to indicate the exact geological range of the genus. In the Salt-range a single form belonging to *Monotrypa* has been detected. It occurs there in the lower division of the Productus-limestone.

1. Monotrypa mastoidea, Waagen & Wentzel, n. sp., Pl. CVI, fig. 1; Pl. CXV, fig. 7.

Corallum attached with a broad extended base to foreign bodies; forming more or less high, bluntly conical elevations, which apparently do not exceed the height of 10mm. Surface of corallum smooth, without monticules. Calices polygonal, very small, mostly not more than 0·2mm. in diameter. very closely arranged with narrow spaces between. The surface is too badly preserved to show whether there were tubercles or not. Corallites tubular, either being fixed directly to a foreign body for a short distance and then becoming erect, or radiating from a short imaginary

axis. Walls very thin in the interior parts of the colony, slightly thickened towards the periphery. Tabulæ tolerably numerous, irregularly distributed. Propagation very distinctly partly by intermural gemmation, partly by fissiparity. In tangential sections, "spiniform corallites" are observable everywhere in the corners of the corallites.

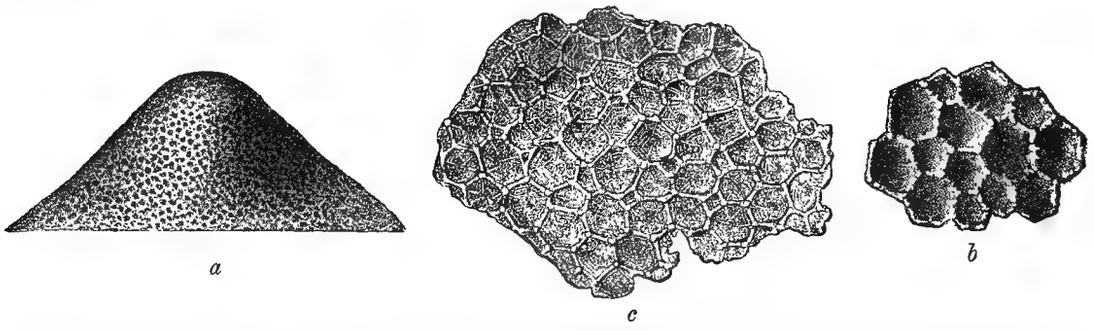


Fig. 31. MONOTRYPA MASTOIDEA, Waagen and Wentzel, n. sp.—Specimen from the lower Productus-limestone of Amb: *a*, the entire specimen, enlarged about six times; *b*, part of the somewhat weathered surface, strongly enlarged; *c*, microscopical section, not very well preserved, showing the thickenings preceding gemmation, and gems in different states of development, enlarged forty times.

This species is very characteristically distinguished from others by its bluntly conical shape and very broad base of attachment. It is, however, doubtful to us if the only specimen at our disposal shows the full development. In the whole manner of growth the present species shows a certain affinity to *Monticulipora wesenbergiana*, Dybowsky, and as this species is partly incrusting and partly arborescent, it is not improbable that also of the Indian species an arborescent form may exist.

Locality and geological position.—The only specimen of this species that is known to us was found at Amb in the coaly sandstones at the base of the lower Productus-limestone attached to a specimen of *Derbyia regularis*, W.

Remarks.—The present species cannot be compared in particular with any hitherto described species of *Monotrypa* proper, but it shows a certain affinity, as has been stated above, to *Monticulipora wesenbergiana*, Dybowsky, from silurian strata of the Baltic provinces. The mode of growth of both forms seems to be identical, but the minute structure is considerably different. Whilst *Mont. wesenbergiana* shows so strongly thickened walls of the single corallites that it must be placed in the genus *Orbipora* of Eichwald, the Indian species exhibits these thickenings only on a very moderate scale and must thus be placed in the genus *Monotrypa*. Thus also the specific difference of the two cannot be questioned.

Genus: ORBIPORA (Eichwald) Dybowsky.

It is barely possible to accept Eichwald as the real author of the genus, as nothing but the name is from him, his two diagnoses of the genus being absolutely useless. Thus the genus can be considered as well founded only after the careful description of it given by Dybowsky in his east-baltic silurian *Chætetidæ*.

Dybowsky characterizes the genus in the following manner: "Corallum polymorphic, corallites tubular with thick walls, which are common to the adjoining individuals, and of a lamellar structure. The lamellæ are bent convexly upward; within the walls of the corallites are string-like, sclerenchymatic thickenings; tabulæ either present or wanting."

According to the views now prevailing in these matters, this diagnosis is again not complete. Dybowsky says nothing of the structure and distribution of the young individuals, a character which has been so ably made use of by Nicholson, nor does he mention the mode of gemmation which is also absolutely required for the right determination of such things. To find out these characters we must turn to Dybowsky's drawings and descriptions of the species.

We then find that *Orbipora* is in all respects like *Monotrypa*, with the sole distinction, that the walls of the single corallites are extremely thickened, whilst they are less so in *Monotrypa*. The existence of "Wandstränge" which is much insisted on by Dybowsky is of no value whatever for the classification, as it depends, as has been shown above by us, solely upon the mode of preservation.

If this latter character, the existence of "Wandstränge," be ignored, then what has been described by Dybowsky under the name of *Monticulipora* falls for the greater part to *Orbipora*, and probably only a single species of Dybowsky's *Monticulipora* must be assigned to *Monotrypa*, the one figured on Dybowsky's Pl. III, fig. 3, which has received no specific designation from him.

That Dybowsky's *Monticulipora* cannot be identified with D'Orbigny's genus has been demonstrated conclusively by Nicholson, who has shown that the typical species of *Monticulipora* bears the characters of *Heterotrypa*, and thus is something widely different from *Orbipora* or *Monotrypa*.

Dybowsky's *Monticulipora* is in all respects identical with *Orbipora*, with the sole exception that the primary mural plate is not resolved into a number of so-called "mural strings," but is either not preserved at all or else is distinctly visible as real primordial wall.

There have been figured by Dybowsky in *Orbipora panderi* thorn-like processes from the interior of the walls which are identical with what has been called rudimentary septa in Favosites. We shall have occasion to describe similar organs in a species of *Stenopora*.

The genus *Orbipora* has a wide geological range and is represented in numbers from silurian up to carboniferous strata.

In the Salt-range we can register only a single species of *Orbipora*, which has been found there in the lower division of the Productus-limestone.

1. Orbipora ambiensis, Waagen & Wentzel, n. sp., Pl. CXV, fig. 2.

Corallum dendroid, branches thin, not more than 2mm. in diameter, forking at intervals. Surface smooth without monticules. Calices roundish or oval, not

very small, generally about 0·3mm. in diameter. Spaces between the calices comparatively broad, furnished with high crests along their middle line, and rarely with tubercles in the corners where several calices meet. Corallites tubular, irregularly radiating from an imaginary axis. Walls of the corallites very thin in the middle of the branches, but with very strong secondary thickenings towards the periphery. Tabulæ very scarce or even entirely absent. Gemmation not very frequent.

This species in its general appearance bears much resemblance to *Geinitzella columnaris*, Schl., which will be described later on in the text. Yet the present form cannot be placed in the genus *Geinitzella*, because the regular transverse wrinkling of the internal casts of the corallites of *Geinitzella* cannot be observed in the present species, and also the structure of the walls is considerably different, as no so-called spiniform corallites are developed.



Fig. 32.—Orbipora ambiensis, W. & W. Specimen from the lower Productus-limestone of Amb, natural size, and enlarged five times.

Locality and geological position.—A single fragment of a branch was collected in the coaly sandstones at the base of the lower division of the Productus-limestone at Amb.

Remarks.—It must be confessed that the materials of this species are very scanty and barely sufficient to characterise it thoroughly, but on the other hand the occurrence of a true *Orbipora* in the lower division of the Productus-limestone is so interesting, that we thought it worth while to describe the form more accurately. Yet we must apologise on these grounds for the briefness of the description.

Among the species of *Orbipora* hitherto described there are several which might be compared to the present species. There is principally *Orbipora arborescens*, Dybowsky, which bears a certain resemblance; the branches are, however, thicker, and the walls still more thickened than in the Indian form. Another form is *Monticulipora ædilis*, Eichwald. It needs only a look at Dybowsky's drawings of this species to be convinced that the form belongs to the genus *Orbipora*. In the thinness of the branches this silurian species very much resembles the Indian one, but the calices are much more elongately oval and placed more regularly in quincunx than in our *Orbipora ambiensis*.

That the species, though resembling *Geinitzella columnaris*, Schl., can be distinguished from it has been remarked above; the absence of those thickenings preceding gemmation that have been called by Nicholson "spiniform corallites" forms a very striking distinguishing character, and besides there is no annular wrinkling.

Sub-family: *STENOPORINÆ.*

Genus: GEINITZELLA, Waagen aud Wentzel, n. gen.

The present genus has been founded by us not only on the investigation of Indian but as well of European materials, which all belong to one and the same species, the well known *Stenopora columnaris*, Schl., which is a common form of the permian beds of Europe. For excellently preserved European materials we are indebted to the kindness of Geheimrath Geinitz of Dresden, who sent us a number of specimens from the Zechstein of Gera; they have been figured for comparison with the Indian materials on Pl. CXII of the present work.

It was noticed many years ago by the excellent observer Schauroth, that the visceral chambers of *Stenopora polymorpha*, as he called it, are provided with transverse wrinkles which are chiefly conspicuous on the internal casts, and he figures (Zeitschr. d. Deutsch. Geolog. Ges., Vol. VI, 1854, Pl. XX, figs. 5-6) two such casts showing this character in a most striking manner. In strongly enlarged microscopical sections this character is much less conspicuous, but our Plates CXIV, figs. 2*d* and 3*b*, and CXII, figs. 2*c* and 2*d* show this peculiarity also sufficiently well to give a fair idea of this transverse wrinkling. These wrinkles establish a very near relation of the forms which are provided with them to *Stenopora*, Lonsdale, and the character seems to us of sufficient importance to found on it a new genus.

Otherwise the new genus agrees in its structure almost entirely with *Monotrypa* or *Orbipora*. The first microscopical investigations of the organisms here under consideration were published by Dybowsky in 1876 in the "Verhandlungen der russischen mineralogischen Gesellschaft." His observations are, however, not quite in accordance with what we have found. Dybowsky considers as the most essential character of the genus the existence of a central cavity (Axenrohr) which extends longitudinally through the branches, and which is described in detail as bearing a distinct wall for itself and consisting of layers of different structure, etc. This "Axenrohr" we have also found in European specimens of *Geinitzella*, but there is not the slightest doubt in our case that it consists of a foreign body, on which the colony of corals has grown. In our case it is probably the spine of a *Productus;* in the case figured by Dybowsky it is probably a *Serpula* or *Serpulites*. That the branches are absolutely of the same structure as in other *Monticuliporidæ*, if the colony has not grown round a foreign body, is shown by our figure Pl. CXII, fig. 2*d*, where the central zone, as in other *Monticuliporidæ*, is perfectly well deve-

loped. Also in our figures, where the "Axenrohr" appears, sometimes layers of different structures can be observed, but they are not constant and are evidently nothing but products of fossilisation.

The colonies are very often not simple, but one colony settled on another, causing the formation of concentric layers, of which the whole corallum appears then composed. This character has been strongly insisted upon by Keyserling, and also Dybowsky lays some stress on it. This composition of concentric layers is, however, not identical, as has been rightly demonstrated by Dybowsky, with what appears in many tabulate corals as caused by all the tabulæ of the several corallites being on the same level. The concentric layers of *Geinitzella* are all perfectly independent colonies. Each colony commences with a thin basal plate of compact sclerenchyma, which is built up of the pedal plates of the several corallites grown together. This plate covers all the apertures of the old tubes and often enters even into their hollows.

Some words may be needed with regard to the figures of the genus given on Pl. CVI, figs. 1, 5, 6, Pl. CXII, and Pl. CXIII. In all the figures on these plates not representing tangential sections, the preservation of the primary mural plate or primordial wall by a white matrix is very conspicuous. Just where the thickenings preceding gemmation, which extend in these forms over very long distances, have been hit by the sections, it looks as if these were open tubes or canals, but the figure 1*e* on Pl. CXIII shows clearly that this is not the case. To the right and to the left are walls of corallites in which are no such thickenings; and in the wall to the right the primordial wall is preserved as a dark line. The thickenings indicated in white have a finely fibrous structure, and are not simply sparry or filled with rock matrix as they should be if they were tubes. Yet more convincing in this respect are the figures on Pl. CXIV: in fig. 1*d* we see the thickenings dissolved into a series of black spots, whilst figs. 2*d* and 3*b* exhibit in what different manners the primordial wall can be preserved.

The thickenings preceding gemmation, which have been called spiniform corallites by Nicholson, are also remarkable in other respects in these forms. If the wall separating two adjoining corallites is not very thick, these thickenings can press one side of the wall into the interior of the visceral chamber of one of the corallites, whereby often a bi-lobed form of the corallites in the transverse section is brought about (compare fig. 4, Pl. CXII), a circumstance which has been figured already by Geinitz in his *Stenopora columnaris* and which has been misapprehended by Dybowsky in his paper on *Fistulipora lahnseni*.

In fig. 1*c* of Pl. CXIV the thickenings show a very peculiar mode of preservation, but this is quite exceptional and can be explained by comparison with the longitudinal section, fig. 1*d*. Again another mode of preservation causes the dendritic figures that have been observed and drawn by Dybowsky.

Thus we can define our new genus in the following manner: Corallum creeping or arborescent, composed of more or less cylindrical corallites which augment

by intermural gemmation or fissiparity and are transversely wrinkled. The walls of the corallites in arborescent forms are strongly thickened in the peripheral parts. The thickenings of the primordial wall preceding gemmation project from the surface of the colonies as little spines, which surround the apertures of the corallites. Tabulæ very rare or nearly absent.

The genus is most nearly related on the one hand to *Orbipora* (Eichw.), Dybowsky, and on the other to *Stenopora*, Lonsdale. From the first of the two it is distinct by its transversely wrinkled corallites and the greater scarcity of tabulæ, and from the second by the absence of the strong periodical thickenings of the walls of the corallites, so very conspicuous in *Stenopora*.

In the Salt-range the genus is represented by two species, one of which is identical with the well known *Geinitzella columnaris*, Schloth. sp., from the permian beds of Europe.

1. GEINITZELLA COLUMNARIS, Schloth. sp., Pl. CVI, figs. 5, 6; Pl. CXII, figs. 1-5 (European specimens); Pl. CXIII, figs. 1-4; CXV, fig. 1.

1813. *Coralliolites columnaris*, Schlotheim: Mineralog. Taschenb., p. 59.
1820. *Encrinites ramosus*, (Brachia) Schloth.: Denkschr. Akad. Münchn., Vol. VI, p. 23, pl. III, fig. 10.
1842. *Ceriopora milleporacea*, Kutorga: Verhandl. Mineralog. Ges. St. Petersburg, p. 28, pl. IV, fig. 5.
1845. *Stenopora spinigera*, Lonsdale: Murch. Vern. Keys., Russia and the Ural mtns., p. 631.
1848. *Stenopora mackrothi*, Geinitz: Verst., p. 17, pl. VII, figs. 8-10.
1848. *Alveolites producti*, Geinitz: Ibid., p. 19, pl. VII, figs. 28-31.
1850. *Stenopora columnaris*, (Schl.) King: Monogr. Perm. Foss., p. 28, pl. III, figs. 7-9.
1850. *Alveolites buchiana*, King: ibid., p. 30, pl. III, figs. 10-12.
1854. *Stenopora polymorpha*, Schauroth: Zeitschr. d. Deutsch. Geolog. Ges., Vol. VI, p, 541.
1854. *Stenopora spinigera*, (Lonsd.) Keyserling: in Schrenk's Reise, II, p. 99, pl. II, figs. 1, 2.
1861. *Stenopora columnaris*, (Schloth.) Geinitz: Dyas, I, p. 113, pl. 21. (excl. fig. 20).
1875. *Stenopora tuberosa*, (Gein.) Toula: Spitzbergen; Neu. Jahrb., 1875, p. 247, pl. X, fig. 4.
1876. *Stenopora columnaris*, (Schloth.) Dybowsky: Verhandl. russ. mineralog. Ges. St. Petersburg.

The external shape of the corallum is very variable, sometimes incrusting foreign bodies, often cylindrical, and sometimes dendroid. The branches do not often become thick, up to 5mm. diameter, but generally are much thinner, about 2mm. Calices round, oval, or polygonal, mostly of very unequal sizes. There are no clusters of larger tubes, nor smooth spaces between the calices. The corallites are mostly round or oval in the peripheral parts of the colony and polygonal with thin walls in the central parts. They are distinctly wrinkled or contracted transversely at intervals, either for their whole extent or only in the peripheral parts where the walls become considerably thickened. The most striking character in thin sections is the remarkably compact nature of the thickenings of the primordial wall, the terminations of which project as spines from the surface of the colonies and which afterwards are transformed into gems. If the specimens are well preserved these thickenings can be followed for a considerable length; they are then always preserved by a white matrix and their extremely compact nature can be well made out. If the preservation is less favourable they

show a somewhat dendritic appearance as has been described by Dybowsky. These dendritic masses, however, appear only when the substance of the thickening is quite dissolved and replaced by mineral matter. That these compact thickenings are not a product of preservation solely but are really a specific feature of the form here under consideration, is shown most clearly by the specimens that have been figured by us on Pl. CXII and CXIII, where the same character is exhibited in absolutely the same manner by European as by Indian specimens.

When the surface of the specimens is perfectly preserved, as happens rather rarely, these compact thickenings project as large spines. What development these spines may attain is shown by our figure Pl. CXII, fig. 3, where the surface of one colony has been covered by another newly formed colony, and where the surface of the old colony has thus been perfectly preserved. The specific name of "*spinigera*," created by Lonsdale for this form, was thus a very appropriate one.

Several varieties have been distinguished within the species by Geinitz, a proceeding that was most appropriate. The forms belonging to the species can be brought very conveniently according to the external appearance into three groups; one, to include incrusting forms, another for arborescent colonies, and a third forming tuberous masses. With this latter group *Stenop. crassa*, Lonsd., was united by Geinitz, but we think that this should not be done, as we consider *Stenop. crassa* as a distinct species. Some of these varieties have been found in India: we are inclined to distinguish the following:—

a. Var. incrustans, Gein., Pl. CVI, figs. 5-6. Besides the peculiarity that it is incrustating, this variety shows also generally the character that it produces very few gems, which caused Mr. King to describe it under the name of *Aiveolites buchiana*. Exactly the same peculiarities we find in the Indian specimens figured on Pl. CVI.

b. Var. ramosa multigemmata, Pl. CXII, fig. 2*a*, 2*b*, Pl. CXIII, figs. 2*a*, 2*b*, 3, 4. The variety "*ramosa*" of Geinitz shows very different appearances according to the scarcity or profusion of gems, and it seems convenient to make a difference between the two forms. The "*multigemmata*" has large interspaces between the openings of the full-grown corallites, and these spaces are covered by numberless little gems or thorns, according to the state of development. This variety occurs also in absolutely the same manner in Europe as in India.

c. Var. ramosa sparsigemmata, Pl. CXII, figs. 1*a*, 1*c*, 4., Pl. CXIII, figs. 1*a*, 1*c*, 1*d*. In this variety the apertures of the full-grown corallites are much closer together than in the preceding and single gems appear between them. This variety also is common to Europe and India.

The *Var. tuberosa*, that was distinguished by Geinitz and that is not of very rare occurrence in Europe, has up to the present not been detected in India.

Locality and geological position.—The species here under consideration is about equally distributed throughout the middle and upper divisions of the Productus-limestone. It has been found at Khura in the top-beds of the middle division, and

west of Khura in the lower beds of the upper division. At Chidru it is not rare in the Cephalopoda-bed, whilst at Káfirkot again it has been found in the middle region of the middle division. From the trans-Indus continuation of the Salt-range there were also some specimens contained in Dr. Verchere's collection, but the exact locality whence they came is not known. It is not possible to give numerical indications as to the frequency of the species at different localities, as an exact determination of these things without microscopical sections is impossible, and it is at the same time impossible to make such sections of every specimen. So much, however, can be said that the species is rather common, and most so west of Khura.

Remarks.—The occurrence of this well known permian species in the Salt-range is again of great geological interest. That the Indian specimens are absolutely identical with the European ones is shown by our plates, where specimens of both countries are placed side by side.

2. Geinitzella crassa, Lonsdale, sp., Pl. CXIV, figs. 1, 2, 3.

1845. *Stenopora crassa*, Lonsdale : in Mürch. Vern. Keys., Vol. I, p. 633, pl. A. fig. 12.
1846. *Stenopora crassa*, (Lonsd.) Keyserling : Petschoraland, p. 183.
1854. *Stenopora crassa*, (Lonsd.) Keyserling : in Schrenk's Reise, vol. II, p. 99 (*pars*).
1861. *Stenopora columnaris*, Schloth. *var. tuberosa*, Geinitz (*pars*) : Dyas vol. I, p. 115, pl. XXI, fig. 20 *(excl. cet.)*.
1875. *Stenopora ramosa* (Gein.) Toula : Spitzbergen ; Neu. Jahrb., 1875, p. 246, pl. X, figs. 2-3. (*male*).

Though the internal structure of the original specimens of this species is not known, yet we venture to identify with Lonsdale's name a number of Indian specimens which are distinct from *Geinitzella columnaris* by a much more robust shape and by some internal characters.

The corallum is always arborescent with very thick cylindrical branches, which have a diameter of mostly at least 10mm. They are sometimes, but not always, composed of different colonies, which are deposited one above the other. Calices always rounded, oval or circular, of very variable sizes, often only a few of the smaller sort being disseminated between the larger ones, but sometimes with a great number of smaller intercalated between the larger calices, so that also in this species a variety with gems in profusion and another with only few gems could be distinguished. The surface only very rarely shows projecting spines.

In thin sections the corallites appear polygonal, with thin walls in the centre of the stems, but becoming considerably thickened towards the periphery, whereby an oval section of the corallites is brought about. Within the thickened part of the walls the thickenings of the primary mural plate preceding gemmation become also in this species conspicuous, but quite differently from those in *Gein. columnaris*. They are much less compact and more or less nodular, often interrupted, and are transformed into gems as soon as they reach the surface and find space for the development of new individuals. Therefore the existence of spines on the surface is of very rare occurrence in this species. Though this latter character can be

found as well on *Gein. columnaris*, yet in that species it is caused by preservation solely, whilst in the present one it is a result of the structural peculiarity of the thickenings preceding gemmation. Septa-like processes occur sometimes in this species.

These characters, together with the more robust shape of the whole colony, seem to us sufficient to distinguish these forms from *Gein. columnaris*, Schloth.

Locality and geological position.—The greatest number of specimens (about a dozen) of this species were collected by Mr. Wynne at Jabi in the upper division of the Productus-limestone. Another specimen was found at Chidru in the Cephalopoda-bed, and besides this there is yet a doubtful specimen from the middle Productus-limestone of Káfirkot.

Remarks.—It is somewhat hazardous on our part to identify the Indian specimens with Lonsdale's *Stenop. crassa*, which was described originally from permian beds of N. E. Russia. Lonsdale's species has been identified by most authors with *Stenopora columnaris*, Schloth., and it seems to us that this identification is quite correct so far as specimens of S. W. Europe are concerned. The very robust form of the true *Gein. crassa*, Lonsd., seems to us restricted to N. E. Europe (Russia) and Spitzbergen and not to occur in Germany or England.

In external shape the Indian specimens are absolutely identical with the Russian ones, and there is every probability that also the internal characters will prove identical.

The evidence before us seemed not sufficient to warrant the introduction of a new name for the Indian coral, and as the probability of its identity with *Geinizella crassa* was very great, we decided on putting the Indian form under this name.

Genus: STENOPORA, Lonsdale.

Under the name of *Stenopora* very different things have been described. It was thus a very meritorious proceeding on the part of Mr. Nicholson, that he returned to Lonsdale's original description and to the study of original Australian specimens; from his investigations we know that all the forms described by Mc'Coy, Geinitz, and others under the name do not belong to the Australian genus, but must be distributed in other genera.

In the Salt-range, specimens agreeing in all respects with the true Australian *Stenopora* are not very rare, and we must admit the plentiful representation of the genus in India.

According to our materials the diagnosis of the genus may be drawn up in the following manner:

Corallum incrusting, arborescent, foliaceous or hemispherical, fixed by its base to foreign bodies, composed of tubular corallites, which are nearly vertical in the centre of the corallum and radiate thence on all sides towards the surface. The corallites are polygonal in the centre of the corallum, with thin walls and very closely

packed together; in their radiating peripheral part they become cylindrical and their walls show regular transversely annular thickenings, which occur in the same manner and at equal distances in a great number of adjoining corallites. These thickenings alternate on the inside of the corallites with periodical contractions of the walls. There are yet other thickenings that extend longitudinally within the walls as in other *Monticuliporidæ;* they are the thickenings that precede gemmation, and project on the surface of the corallum as little spines between the single corallites. The calices on the surface of the corallum are partly quite open, partly closed by a kind of hemispherical lid. They are of rather unequal sizes. Tabulæ are present within the corallites at very irregular distances, but they are either concave or convex, not flat. Mural pores and distinct well-developed septa are absent. The corallum is composed of several concentric layers each of which is a separate colony. The single colonies increase by intermural gemmation chiefly.

From this diagnosis it appears that the structure of the genus is absolutely like that of other *Monticuliporidæ*, and that the only difference for instance between *Orbipora* and *Stenopora* consists in the periodical annular thickenings exhibited by the walls of the corallites in the latter genus, whilst in *Orbipora* the thickening of the walls in the peripheral parts of the corallum is equal throughout.

These periodical thickenings of the walls must naturally cause a different aspect in the tangential sections, according to whether they cut just through these thickenings or not. In the first case the interiors of the visceral chambers appear reduced to comparatively thin tubes, which are encircled by a ring of sclerenchyma, which often can be distinguished as composed of concentric lamellæ (Pl. CIX, fig. 2*a*). If however the section cuts through the intervals between the thickenings, one sees also generally a ring of sclerenchyma within the dark lines of the primary mural plates (Pl. CX, fig. 1*c*, Pl. CXI, fig. 1*a*), but this ring is either of very moderate thickness or is even almost entirely absent, so that the visceral chambers appear even more or less polygonal. The whole section appears then to a certain extent as if taken from the central part of the corallum.

The inexplicable facts mentioned by Nicholson and Etheridge with regard to the present genus in Ann. and Mag. Nat. hist., Ser. V, vol. IV, p. 272, find a very natural explanation in what has been said of the preservation of the walls of the *Monticuliporidæ* in general in the introduction to the family. The appearance in tangential sections, as if the walls of the several corallites were not in contact throughout, is brought about solely by bad preservation. That the walls are in reality everywhere in contact is shown conclusively by our figures.

The fact that on natural fractures the tubes seem to be in contact for short distances only is caused by the circumstance that in *Stenopora* the substance of the walls of the corallites is very easily destroyed, and that then in natural fractures the internal casts of the tubes are exposed and not the tubes themselves. These internal casts show periodical constrictions, corresponding to the periodical thickenings of the walls; the thin parts of the walls alternating with the thickenings are

then often preserved, and at these places the casts of the tubes appear to be in contact.

Longitudinal sections in which the walls of the corallites are perfectly well preserved show conclusively that they are in perfect contact throughout, and that the periodical thickenings, like the thickenings of the walls of other *Monticuliporidæ*, are made up of doubly conical layers of sclerenchyma, which meet in the middle along the primary mural plates.

A most fundamental difference between *Stenopora* and the *Monticuliporidæ* consists, according to Nicholson and Etheridge, in the existence of mural pores in the former genus. Mons. de Koninck concurs in this respect with the above authors, and consequently transfers the species *Stenop. ovata*, Lonsd., to the genus *Favosites*.

As regards Mons. de Koninck's observations, they were made evidently on internal casts, as his figure most distinctly exhibits. Now such casts are certainly not very apt for the observation of such fine structures as mural pores, and an error is very easily made. Not much better seem to have been the materials on which Messrs. Nicholson and Etheridge operated. They state that the mural pores could be most easily seen on the outside of the tubes, if examined with the microscope. Now the outside of the tubes is only exposed distinctly on weathered fractures or on fractures of specimens which have been subject already to a certain extent to weathering; quite fresh specimens always show fractures which either do not expose the outside of the tubes, or on which nothing at all can be seen, except by means of a preparation of thin slides. On weathered surfaces, however, the walls of the tubes are always so much deteriorated that openings may easily appear where originally there were none. On weathered fractures we frequently were in a position to observe such openings; they were, however, decidedly of a secondary origin. The figure reproduced by Nicholson on page 81 of his work on *Monticulipora* represents only an internal cast, where the substance of the walls has entirely disappeared. The pores are evidently nothing but accidental grooves. As regards the longitudinal sections figured by Nicholson and Etheridge, in which mural pores are said to be visible, we have a great suspicion, as they appear in the middle of the visceral chamber, that these pores are nothing else but what we figure Pl. CXI, fig. 1*c*, that is, the transverse section of some of those protuberances which have been called rudimentary septa in *Favositidæ* or *Chætetidæ*. Other longitudinal sections, like those of *Stenop. howsii* or *Sten. tasmaniensis*, show no trace of mural pores. Among the great number of microscopical sections we prepared of species of the present genus, there is certainly not a single one that shows a trace of a mural pore.

A word must yet be said about the tabulæ. These are very scarce in the Indian species of the genus, and at the same time they are very strongly curved. In other species they seem to be more frequent, and in the carboniferous *Stenop. howsii* Nicholson has described incomplete tabulæ which bear in the middle a round perforation. This character is certainly not of general occurrence in the genus.

The genus has been observed to occur up to the present in the mountain-limestone of Europe and in beds of the age of the coal-measures of Australia. To these are added four species in India which are mostly of permian age. One of these is identical with an Australian form.

1. Stenopora ovata, Lonsdale, Plate CX.

1844. *Stenopora ovata*, Lonsdale: in Darwin's Geol. Obs. Volc. Islands, p. 163.
1845. *Stenopora ovata*, Lonsdale: in Strzelecki's Phys. descr. of New South Wales, p. 263, Pl. VIII, fig. 3*a*, *b*.
1872. *Monticulipora tumida* (pars) Koninck: Nouv. Rech. Terr. Carb. Belgique, p. 143.
1877. *Favosites ovata*, (Lonsd. sp.) Koninck: Pal. Nouv. Galles du Sud., pt. III, p. 156, Pl. III, fig. 5.
1879. *Stenopora ovata*, (Lonsd.) Nicholson and Etheridge: Ann. Mag. Nat. Hist., Ser. V, vol. IV, p. 274, Pl. XIV, fig. 1.

Corallum in the beginning incrusting, later on arborescent with cylindrical and forking branches. Thickness of the branches very variable, according to Mons. de Koninck varying between 3 and 15mm; but generally not more than 9mm. in diameter. Branches often composed of several successive colonies, forming concentric layers one above the other. Surface smooth without monticules or maculæ. Calices rounded with acute margins on which often little spinules in varying numbers are placed; many smaller calices intercalated between larger ones. Corallites tubular. Walls considerably thickened at intervals, and presenting in longitudinal sections the appearance of a string of beads. Thickenings either narrowly annular or broad, both sorts alternating indiscriminately. Six to ten such thickenings within a length of one line (2·2mm). Tabulæ present, but very scarce.

In internal casts the tubular corallites appear alternately swollen and constricted, like a string of beads, according to the impressions that have been left behind by the periodical thickenings of the walls.

The calices on the surface of the colonies are of an extreme fineness. There are at least three within the distance of 1mm.

Locality and geological position.—The species is not a very common one in the Salt-range, nevertheless it has a rather large geological range. It has been found in the middle Productus-limestone trans-Indus at Kiri, and in the upper Productus-limestone at Nanga and at Jabi, above the Cephalopoda-bed. Everywhere the species appears to be rather rare.

Remarks.—The present species was originally described from Australia, from beds which must be placed on a level with the coal-measures of Europe. Though the Indian specimens occur in strata of permian age, yet it seems to us that they cannot well be distinguished from the typical Australian form. It is true, there exist some slight discrepancies, but they seem to us not quite sufficient for the distinction of a new species. Nicholson and Etheridge say that in the Australian specimens generally there are only six swellings of the walls within the distance of one line, whilst in our specimens very often more than six, up to ten, occur; but as

the number is very variable, and as it appears also from Lonsdale's original drawing that these swellings even in Australian specimens are very unequally distributed, we thought it not fit to consider this variability as a sufficient character for the distinction of a species. Another discrepancy is of still less importance; this is the absence of the little spines on the surface of the Indian specimens. Whoever knows how much the appearance of the exterior of a colony depends on preservation will readily ignore this peculiarity.

2. Stenopora nicholsoni, Waagen and Wentzel, n. sp., Pl. CIX.

Corallum thick, cylindrical, bifurcating, thickness of the branches about 15mm. The calices are mostly about 0·3 mm. or somewhat less in diameter. They are generally not of very unequal size, often closed by a hemispherical calcareous mass, in which a hole appears in the middle when weathered. There are in the specimens at our disposal no, or only very few, small spines or tubercles surrounding the calices. Corallites tubular, in the centre of the colony polygonal, in the peripheral parts more or less rounded or oval. Walls thin in the centre of the branches, in the peripheral parts irregularly thickened at intervals, and appearing in the longitudinal section like strings of small differently shaped beads. There are within the length of one line (2·2 mm.) 14 to 16 such thickenings. Thickenings of the primordial mural plate preceding gemmation are not very numerous. Tabulæ scarce, very strongly vaulted.

On natural fractures of the stems the substance of the walls has generally entirely disappeared by weathering. The corallites appear then in the centre as angular columns separated from each other by deep furrows, and in the peripheral parts they look like strings of beads, alternately swollen and contracted. The swollen parts of these internal casts are generally on the same level in adjoining corallites and approach each other very closely, whilst in the contracted parts they recede. Now between the swollen parts very often the substance of the walls is still partly preserved, and the adjoining corallites appear as if blended together at these places, whilst in the intervals the wall-substance has been quite destroyed and gaps or holes appear, and it looks as if the corallites were here not in contact but widely apart from each other.

Locality and geological position.—This is a very rare species; only a single specimen of it has been detected up to the present. This was found in the upper Productus-limestone east of Katwáhi. This specimen is also so far remarkable in being incrusted at its upper extremity by *Stenop. ovata*, Lonsd.; all the lower part, however, is solely *Stenop. nicholsoni*.

Remarks.—The present species is most nearly related to *Stenop. ovata*, Lonsd., for which it could easily be mistaken. The chief difference consists in the number of swellings exhibited by the walls. Whilst in *Stenop. ovata* as a rule only six such swellings are observable within a length of one line, which number only exception-

ally amounts to 10, there are in *Stenop. nicholsoni* regularly 14 to 16 such swellings within the same length. The striking difference that exists in this respect between the two species is most clearly exhibited by fig. 3 on Pl. CIX, where the interior part consists of *Stenop. nicholsoni*, whilst on the outer part *Stenop. ovata* forms an incrustation.

Other species can barely be compared to the present one. *Stenop. tasmaniensis*, Lonsd., has a still much smaller number of swellings of the walls; *Stenop. jacki*, Nich. and Etheridge, is a far more elegant species, with much thinner branches; and *Stenop. crinita*, Lonsd., forms tuberous masses, with corallites having much less numerous constrictions.

3. Stenopora chætetiformis, Waagen & Wentzel, n. sp., Pl. CXI.

Corallum cylindrical, simple or forked, diameter of the branches 7 to 13 mm. Calices rounded, of not very different sizes, generally about 0·3mm. in diameter. Interspaces between the calices either carinated, if well preserved, or with little tubercles or grooves, according to preservation or different specimens. Corallites tubular, polygonal in the beginning, but very soon getting thickened walls and then exhibiting a roundish or oval section; ascending at first vertically and then very slowly bending outward by degrees to reach the surface at about right angles. Walls at first thin, but very soon, already in the vertically ascending part of the corallites, showing periodical thickenings of which 9 to 12 can be counted within a length of one line (2·2mm.). Interiors of the visceral chambers provided with numerous, very irregularly distributed, protuberances identical with what has been called in *Favositidæ* and *Chætetidæ* "rudimentary septa." Tabulæ scarce.

The structure of the walls is very visible in the preparations we have made of the species. The primary mural plate is preserved as a thin black line, and the thickenings of this plate, which generally precede gemmation, are preserved by a white and very compact matrix, quite in the same manner as in *Geinitzella columnaris* described above. The thickenings of the walls are very distinctly composed of doubly conical layers. The thickenings themselves are very irregular. In every section the protuberances of the walls, or "rudimentary septa," form a very conspicuous feature. They are of very variable development, sometimes short and thick, sometimes thin, long, and straight, sometimes bent upward, but always they are of an approximately circular section. The bent nature of these protuberances often causes them in tangential sections to appear in the middle of the visceral chambers, without being apparently united to any of the walls (see fig. 1*b* and 2*c* of Pl. CXI). A very strange appearance is presented by them when cut by a longitudinal section just at the base on the surface of the wall. They appear then as small circular sharply defined spots which might well be compared to mural pores, but one sees distinctly that they are not hollow but that the substance of the wall passes compactly below them (Pl. CXI, fig. 1*c*).

The distribution of these protuberances is extremely irregular. Sometimes they are united in little groups, sometimes they are single, and there are also large stretches of wall which bear no protuberances at all.

The tabulæ are scarce in this species also, but they are less strongly vaulted than in *Sten. nicholsoni*.

Locality and geological position.—This is the most common species of *Stenopora* occurring in the Salt-range. The species seems to be restricted to the upper Productus-limestone and has been found in numerous specimens at Khund Ghat and at Jabi, above the Cephalopoda-bed.

Remarks.—It is barely necessary to indicate how the present species could be distinguished from its congeners, as in thin sections the difference from all other species is extremely striking. Without thin sections, however, this species can as little be recognised as all the others, as there are no external characters upon which the internal ones could be judged.

4. STENOPORA HEMISPHERICA, Waagen & Wentzel, n. sp., Pl. CVI, fig. 2.

Corallum hemispherical, forming large thick masses. Calices roundish or more or less polygonal, very small, generally not more than 0·2mm. in diameter, of not very unequal sizes. Spaces between the calices narrow with a sharp edge, sometimes with tubercles, chiefly in the corners where several calices meet. Corallites tubular, radiating in all directions from one point, with thin walls in the middle, and slightly thickened ones towards the periphery. Walls with periodical swellings, which are, however, not very strongly prominent, in accordance with the moderate thickening of the entire walls. There are four to six such swellings within the distance of one line (2·2mm.). Gemmation not very frequent. Tabulæ present but scarce.

The specimen of this species is, we regret to say, in a rather bad state of preservation, and we are therefore unable to give figures of the thin sections we prepared. Though all the characters mentioned in the above diagnosis can be made out, yet this can be done only with difficulty.

The specimen from which the above diagnosis has been drawn up is 24mm. high and 21mm. broad.

Locality and geological position.—The only specimen of the species that has been found up to the present was collected at Amb, in the dark sandstones at the base of the lower Productus-limestone.

Remarks.—The black coaly sandstone in which this species is preserved is not very favourable for the preservation of finer details, and thus the description of the species must be rather brief. The whole mode of growth indicates at once a species entirely different from all those previously described, and reminds very much of *Favosites*.

Among the species described by Lonsdale from Australia *Stenop. informis* seems to be rather nearly related to the one here under consideration, as it also forms

tuberous or hemispherical masses, but Lonsdale says, that the diameter of the internal casts of the tubes in the Australian species is about a quarter of a line, a diameter which so far deviates from the diameter of the corallites in the Indian specimen, it being nearly three times as large, that we do not think it possible to unite the Indian specimen with *Stenop. informis.*

Of the other species of the genus hitherto described apparently none can be compared more in detail to the present one, all of them exhibiting an entirely different mode of growth.

Sub-order: TETRACORALLA, *sive* Rugosa.

Family: *EXPLETA.*

Sub-Family: *PLEONOPHORA.*

Genus: LONSDALEIA, McCoy.

The materials of rugose corals occurring in the Salt-range are very limited, being restricted to a few species, and thus we are not in a position to add any new facts with regard to the general classification of the whole sub-order. We therefore simply accept Dybowsky's classificatien, as this seems to us the most natural one that has been proposed up to the present. It has also been introduced in Zittel's Handbook.

As regards the genus *Lonsdaleia* itself, there has been published a circumstantial description and re-definition of it by Thomson and Nicholson in the Ann. and Mag. Nat. Hist., 1876, and the statements there published, chiefly with regard to the historical account, barely need any further remarks.

Yet with regard to the definition of the genus, it seems to us that the authors confined themselves too exclusively to the facts deducible from the few species of which they had been able to prepare thin sections; so that if one were to adhere strictly to the definition as proposed by Thomson and Nicholson, even the greater part of the species described by McCoy himself under the name would have to be excluded from the genus.

The character upon which the greatest stress is laid by Thomson and Nicholson is the circumstance, that in the species investigated by them the septa are restricted to the median tabulate portion of the calices and do not reach the outer wall, except perhaps sometimes in a rudimentary and imperfect state; the outer portion of the calices being occupied by an irregularly vesicular tissue. Among the numerous slices we prepared of the species of *Lonsdaleia* that occur in the Salt-range, we have however found that in different calices of one and the same corallum this character varies greatly. In some of the calices the vesicular tissue occupying the outer zone is well developed, and the septa stop where this tissue begins, thus not reaching the outer wall; while in other calices, and this occurs in the majority of cases, the septa

very distinctly reach the outer wall. Even in one and the same calix one side shows sometimes the vesicular tissue and short septa, whilst the other is provided with septa reaching distinctly to the outer wall. We have figured such a case of development on Pl. C, fig. 6. This has, however, already been very often observed; Quenstedt, for instance, figures in his Petrefaktenkunde Deutschlands, Abth. I, Vol. VI, Pl. 162, fig. 32, a specimen of *Cyathophyllum crenulare*, Phill. (as he calls it), which shows in some of the calices septa reaching to the outer wall, whilst in others they are separated from this wall by a distinct zone of vesicular tissue. Thus we think that too great stress should not be put on the character of the septa reaching the outer wall or not. It cannot be denied that numerous vesicles, or even a vesicular tissue, is always present in the genus *Lonsdaleia*, and our figures, chiefly the longitudinal sections, Pl. C, fig. 4 and Pl. XCIX, fig. 2*c*, very distinctly show such, but they are generally, in the Indian species at least, not developed in such an extreme manner as to obliterate the septa.

Another organ which needs some consideration is the so-called accessory wall, which very often separates the vesicular zone from the central tabulate area. In the majority of species of *Lonsdaleia* this wall is very conspicuous, but in others it is not, as has also been stated by Nicholson. Generally, the accessory wall appears where the secondary septa terminate; sometimes, however, it coincides with the termination of the primary septa and then approaches very close to the columella. In all the species of *Lonsdaleia* septal dissepiments are of rather frequent occurrence; if now these are arranged so as to form a circular zone, then an accessory wall is formed, if not, then no accessory wall is produced. This mode of production of the accessory wall also explains the great variability that exists with regard to its position in different species. Nevertheless, the existence and position of such an accessory wall seems of greater value for classification than the existence or absence of a vesicular tissue in the peripheral zone of the single calices. Whilst this latter varies within one and the same corallum in the different calices, the former appears very characteristic for certain species, and according to the development and position of the accessory wall several groups of forms may be distinguished within the genus. Whether the accessory wall is rather removed from the columella or in close proximity of it, it always marks off a central zone, which is solely occupied by tabulæ, and where vesicles are absolutely absent; whilst the vesicles again appear only outside of the accessory wall. The septa are generally not stopped by it, but extend also outside of it.

Within the accessory wall extends the tabulate area, as it is called by Thomson and Nicholson. This area is of very varying extent, sometimes broad, sometimes very narrow, or even sometimes entirely filled up by the extremely thick columella. The tabulæ are mostly rather closely set, more or less horizontal or ascending towards the outer region of the calix, and are sometimes slightly vesicular.

The very thick columella has always a structure of its own, independent of the remainder of the calix. Generally it is so compact that it weathers out separately,

and appears then, if separated from the rest, as a thin rod. Looked at with a lens, this appears longitudinally striated, but the striæ are sometimes twisted like the thread of a screw, sometimes not, and in one and the same colony calices with twisted, and others with straight, columellas may be found. If examined under higher magnifying powers in thin sections the structure of the columella appears very peculiar. In one and the same colony the centre is sometimes occupied by a lamellar plate, sometimes not, from which waving lamellæ in irregular numbers radiate in all directions. These radiating lamellæ are always present, and cause either the longitudinal striation or the twisted appearance of the columella. Between these, in transverse sections, numerous dissepiments appear, which are shown by longitudinal sections to form regula tabulæ, which are sometimes somewhat vesicular as in Pl. C, fig. 4, or quite regularly arranged, as in Pl. XCIX, fig. 2*c* or Pl. CI, fig. 1*d*, 3*c* (these latter figures have been by accident inverted, upside down). These tabulæ are of a conical shape with the apex directed upward towards the visceral chamber of the animal. We see from all this how variable the structure of the columella even in one and the same colony may be; and under these circumstances it may be termed a very fortunate proceeding on the part of Prof. Lindström, when, in his "Index to the generic names applied to the corals of the palæozoic formations," he considers the names *Dibunophyllum*, *Aspidophyllum*, and *Rhodophyllum* of Thomson and Nicholson as synonyms (partly with a query, partly without) of *Clisiophyllum*.

The propagation of the forms belonging to the genus *Lonsdaleia* is a kind of gemmation that comes within what has been called "tabular gemmation" by Koch. This gemmation occurs in the ordinary manner in the astræiform species, but is modified to a certain extent in the fasciculate forms. Both modes of gemmation have been figured by us, the first Pl. C, fig. 3*a*, the second Pl. CXV, figs. 3, 4.

In the Salt-range the genus *Lonsdaleia* occurs in very great numbers, but though the individuals are plentiful yet the number of species is limited.

We can distinguish two groups of forms, both having but little affinity to hitherto described species. In one of these groups the tabulate area is very small, no proper accessory wall exists, nor any vesicular tissue in the peripheral parts. In the other group the tabulate area is entirely filled up by the enormously thick columella.

The first group is represented by two species, which both are astræiform, and rather nearly related to each other, forming together a little group which will best be termed, Group of *Lonsdaleia salinaria*, W. and W.

The second group contains again two species, which are in many respects quite aberrant forms.

All the species of *Lonsdaleia* occurring in the Salt-range have been found in the coral-limestones of the middle Productus-limestone, only one species extending also into the upper division.

Group of *LONSDALEIA SALINARIA*, Waagen and Wentzel.

1. Lonsdaleia salinaria, Waagen and Wentzel, n. sp., Pl. C, figs. 1, 3, 4.

Corallum astræiform, forming large irregular masses. Corallites prismatic, five to seven-sided, of somewhat unequal size, generally 9 to 10mm. in diameter, separated from each other by well developed exothecal walls. Calices in the peripheral region but little excavated, with a more strongly deepened central part surrounding the columella. Columella not extraordinarily thick, very strongly projecting, either round or slightly compressed laterally, provided with numerous vertical lamellæ, which are generally not twisted. The projecting part of the columella is very easily destroyed by weathering (Pl. C, fig. 1*d*), and even the entire calices are often quite smoothed down by the same process (Pl. C, fig. 1*e*). Of primary septa there are about 20 to 24 (Pl. C, fig. 3*a*), between which an equal number of secondary and tertiary septa are intercalated, each of them shorter according to its position. None of the septa reach the columella, all stopping short of it, though approaching it very closely. Well-preserved calices give an impression as of a secondary wall from which the calices suddenly deepen, but in thin sections nothing of the kind can be observed.

In thin sections it is seen that the septa extend uninterruptedly from near the columella to the outer wall of the calices, and that no distinct peripheral vesicular zone is developed as in other species of *Lonsdaleia*. The tabulate area is restricted to a quite narrow zone immediately surrounding the columella, and outside of this zone the tabulæ very soon change into a vesicular tissue; the vesicles, however, being restricted to the spaces between the septa and appearing more or less as interseptal dissepiments.

The tabulæ very distinctly cross the narrow tabulate area, but find their chief development only within the space of the columella where they form somewhat irregular conical elevations (Pl. C, fig. 4), but also in this region they are somewhat vesicular.

The columella is limited off on all sides by something like a regular wall, formed by the vertically ascending tabulæ. In the interior the columella shows many radiating plates, which either start from an imaginary central axis, or from a median transverse lamella. The latter is chiefly the case when the columella appears laterally compressed. Between these radiating lamellæ many dissepiments exist, which very probably have to be brought into connection with the tabulæ.

Locality and geological position.—This species is, excepting *Lonsd. indica*, the most common species of corals occurring in the middle Productus-limestone, and forming there the coral reefs. It has been found in this geological position at Virgal (2 specimens), at Vurcha (1 specimen), at Musakheyl, and trans-Indus by Mr. Wynne at Omarkheyl (1 specimen). In Dr. Verchere's collection there was a specimen marked "Rotta Roh," and another "Punjab."

Remarks.—The present species in its general appearance has a certain resemblance to *Lonsd. floriformis*, Flem., from the mountain-limestone of Europe; but on a closer examination one finds that the relation to Fleming's species is only a very distant one. *Lonsdaleia floriformis* has been examined and figured already many times, and in all cases it has been found that there exists a distinct zone of vesicular tissue in the peripheral parts of the corallites, that a distinct secondary wall is present, and that there is marked off by the latter a distinct and rather large tabulate area. Of all this there is nothing to be observed in our *Lonsdaleia salinaria*. Thus there cannot be any doubt that our species is different from *Lonsd. floriformis;* it belongs even to a quite different group of forms.

The group of forms to which *Lonsd. floriformis* belongs is rather plentifully represented in the mountain-limestone, chiefly by this species itself. In the upper carboniferous beds of Russia (Miatchkowa) *Lonsd. floriformis* seems to be replaced by another but very nearly related species, which belongs to the same group, and might best be quoted under the name of *Lonsd. papillata*, Fischer sp. This species has been well figured by Trautschold, and can be distinguished from *Lonsd. floriformis* proper by the circumstance that the septa very distinctly extend outside of the accessory wall to the outer wall of the corallite, no vesicular peripheral zone being developed. In this respect it approaches more closely to our *Lonsd. salinaria* than does *Lonsd. floriformis*, but otherwise it is quite as distinct.

Of the group of forms on the contrary to which our *Lonsd. salinaria* belongs, not a trace has been detected up to the present, so far as we are aware of, in truly carboniferous strata, and thus this group seems to be restricted to permian beds; it has however not yet been found elsewhere than in the Salt-range.

2. Lonsdaleia wynnei, Waagen and Wentzel, n. sp., Pl. XCIX, fig. 2, Pl. C, figs. 5, 6.

Corallum astræiform, composing large irregular masses. Corallites prismatic, five to seven-sided, with very thick compact walls. Calices large, generally of a diameter of 11 to 16mm., irregularly infundibuliform with a flattened peripheral and a deeply sunk median part. Walls dividing the calices strongly projecting. Columella thick, generally twisted, not much projecting. The calices do not, generally, present the appearance as if there were a secondary wall. Septa mostly very much thickened by a secondary deposition of stereoplasma. There are generally 20 to 24 primary septa, which are the longest, and as many secondary ones, which are shorter; between these a number of short septa of lower orders are intercalated.

In thin sections it can be distinctly seen that all the septa reach the outer wall of the corallites and are not lost in a peripheral vesicular zone. Vesicles are present in great numbers, but they all appear as interseptal dissepiments. There is not a trace of a distinct accessory wall. The tabulate area is very small and restricted to the space between the termination of the primary septa and the columella. None

of the septa reach down to the columella but all stop short of it. The primary septa terminate with a blunt somewhat thickened end. The columella is thick and cylindrical, not compressed as in the preceding species; its structure is tolerably regular; there are many radiating lamellæ, somewhat variable, mostly twisted, as can often be well observed in thin sections. In longitudinal sections a great number of tabulæ appear; they are chiefly distinct within the columella and in the zone that intervenes between it and the termination of the primary septa. Outside of this they are soon lost between the numerous vesicles that fill the spaces between the septa. Within the columella they form flat upright cones, in the tabulate area they are horizontal, and outside of it they quickly ascend, forming many vesicles. The structure of the vesicles is often singularly folded.

Locality and geological position.—The present species is considerably scarcer than the preceding one. It is, however, also restricted to the middle division of the Productus-limestone. It has been found up to the present only at a single locality, at Katta, where two specimens were collected.

Remarks.—The present form is on the whole very nearly related to the preceding one. It differs however from *Lonsd. salinaria* by its considerably larger calices, by which character, even without thin sections, the two species may readily be distinguished. According to the thin sections we have prepared it appears that in the more intimate structure *Lonsd. wynnei* deviates from *Lonsd. salinaria* by the mostly round form and twisted condition of the columella, and by the less vesicular development of its tabulæ.

For the distinction of *Lonsd. wynnei* from *Lonsd. floriformis* and its allies the same characters can be adduced that have been quoted already as distinctive between *Lonsd. floriformis* and *Lonsd. salinaria*.

Aberrant species.

3. Lonsdaleia indica, Waagen and Wentzel, n. sp., Pl. CI, figs. 1—3., Pl. CXV, figs. 3, 4.

Corallum compound, composed of columnar, more or less cylindrical, tolerably straight, perfectly free corallites, united together only at the places where one takes its origin from the other by gemmation. Corallites only in very rare cases very nearly approached or nearly blended together. Calices small, never more than 6 to 8mm. in diameter, regularly infundibuliform, never showing the appearance as if a secondary wall was present, never very deep. Columella very thick, occupying not quite one-third of the diameter of the entire calix, never twisted, rather strongly prominent, so compact that it sometimes weathers out and is found separately. Septa not numerous; there are about 20 primary and as many secondary septa, all uniting at the periphery to form a distinct outer wall, which shows a longitudinal striation (Pl. CI, fig. 2).

In thin sections one sees that the primary septa only partly stop short of the columella, whilst another part of them reaches it well, and unite even with the radiating lamellæ within the columella. Between the septa a great number of interseptal dissepiments are present, which, though they often occupy more or less a central area, yet never unite to form a distinct accessory wall. In transverse sections the columella is very distinctly marked off by a proper wall. In the middle it shows a central transverse lamella, from which smaller ones radiate in all directions. These are again interrupted by some concentric lamellæ. In longitudinal sections one sees that the outer wall of the columella is made up of vertically ascending tabulæ, which slowly bend towards the centre and form blunt cones, one in the other. These are traversed by vertically ascending lamellæ which correspond to the transverse and radiating lamellæ of the transverse sections. It is remarkable that in longitudinal sections there can barely any tabulæ be observed outside of the columella, unless the steeply ascending lines in fig. 3*c*, Pl. CI, on both sides of the columella should be considered not as irregularly cut septa but as tabulæ. In any case the arrangement of the tabulæ is exceptional; and on this ground it might even be proposed to distinguish the present form as a proper genus. Just along the outer wall of the corallites there is a thin, irregular zone of vesicles.

Locality and geological position.—This is one of the commonest species of corals in the Salt-range. It finds its chief development in the coral-beds of the middle Productus-limestone, but extends also, though more rarely, into the upper division. Specimens of it have been collected in the middle division east of Katwáhi (1 specimen), in the Chittawán (1 specimen and many fragments), at Vurcha (1 specimen), at Chidru (1 specimen), on the road from Chidru to Musakheyl (4 specimens), at Virgal (many fragments), and above Nursingpohár (1 specimen). Trans-Indus it was found by Mr. Wynne at Kiri (1 specimen), and there is also a specimen from Dr. Verchere's collection marked "Punjab."

In the upper Productus-limestone the species occurred in the mountains east of Katwáhi, in the section at Khura (only fragments), and trans-Indus at Bilot (1 specimen).

Remarks.—The present species so far deviates from all the others of the genus *Lonsdaleia* that a more detailed comparison with any of them seems unnecessary. The transverse lamella which forms the centre of the columella recalls to a certain extent the genus *Lithostrotion*, but the whole structure of the entire very thick columella so very nearly agrees with that of *Lonsdaleia salinaria*, that if we do not prefer to consider this form as a proper genus, we must place it in the genus *Lonsdaleia*.

The preservation of some specimens of the present species is singularly good, and some of the thin sections we have prepared allow of the application of very high magnifying powers. In consequence of this the structure of the septa can be very well studied, a circumstance which is of some interest with regard to certain observations made by Koch and von Heider. In Pl. CI, fig. 3*b*, we have given the

representation of part of a section, very strongly magnified, which shows two important points, first, that the septa are not equal in structure throughout, and second, that the outer wall of the corallites is no proper organ by itself but is formed only by the lateral joining of the septa.

The septa are distinctly composed of two parts, a central one, which is of a dark colour, and a peripheral or coating one, which is light-coloured and finely fibrous. The dark-coloured part, which can, however, when differently preserved, appear as a distinct white line, represents what has been called by Koch the "primordial stripe" or primordial septum. According to Frech's observations it would appear not improbable that this primordial septum itself is again produced by the blending together of a number of septal spines. This bears on its surface secondary thickenings which are of a different structure. The primordial septa extend to the outer side of the corallites, here slightly projecting and causing thus the longitudinal striation which is exhibited on the outer surface of these corals. The secondary thickening fills the spaces between the primordial septa in the peripheral parts of the corallites, thus completing the outer wall. Now in this outer wall, in the spaces between the primordial septa, fine dark lines have been observed by Koch, which he thought were the traces left behind by the sarcosepta, which thus were encased and fixed by the sclerosepta. Heider, however, opposes Koch's views and declares these dark lines to be cracks produced by the process of grinding down the specimens. That this latter view is the right one is shown by our drawing, where the wall is quite complete and no such dark line is observable within the wall between the primordial septa. With this, moreover, Koch's views as to the growth of the corals are refuted, and Heider's opinion, that the animals regularly ascend in their tubes in the same degree as they deposit calcareous matter behind them, appears well founded. Numerous observations, tending to the same purpose, have recently been published by Dr. Frech, in the Zeitschr. d. Deutsch. Geolog. Ges. 1885, p. 928.

Another point which requires some consideration in this form is the mode of propagation, which is a rather singular one and has been figured by us Pl. CXV, figs. 3-4. Already, however, by Thomson and Nicholson, very exact figures of the process of gemmation in a similar form (*Lonsdaleia rugosa*, McCoy) have been given, and they are very well in accordance with what we have seen in the Indian specimens. The new corallite, as has been already observed by the above-mentioned authors, takes its origin in the vesicular tissue forming, in most species of *Lonsdaleia*, a peripheral zone in each corallite. The daughter animal deviates, however, in its direction more or less strongly from the mother animal. In *Lonsdaleia rugosa* the two form together an acute angle, whilst in the Indian form the young one proceeds at right angles from the side of the mother animal. At first the young animal is simply cup-shaped, and possesses as gifts from its mother nothing but the outer walls and a little vesicular tissue, the septa being still quite rudimentary. Later on the septa become well developed, mostly only after the young individual has again bent at right angles to its former direction, now ascending vertically. In this

state the primary and secondary septa are not yet very much different in length, but the bilateral structure of the rugose corals is developed very distinctly, a kind of septal fossula being present, indicated by two septa which very strongly diverge, whilst opposite there is an exceptionally strongly developed septum. Somewhat later the columella is developed. Its first state could not be observed by us; we find it in our figure already in a perfect state, with its radiating lines and dissepiments. Our fig. 3 on Pl. CXV, represents such young corallites in different stages of development, some of them still quite without a columella, another with a columella but otherwise not yet fully developed, all of these being badly deformed by want of space, being crowded together between some old full-grown individuals.

The gemmation itself, which is thus exhibited by these compound forms of *Lonsdaleia*, cannot exactly be classed under any of the schemes pointed out by Koch in his work on the gemmation of corals, and referred to above, page 858. Nevertheless it seems to us to be most nearly related to the mode of gemmation that occurs in the astræiform species of the genus, and which is absolutely identical with what has been called by Koch a "tabular gemmation." It has been stated above that the young individuals take their origin in the vesicular zone that is developed in the peripheral part of most species of *Lonsdaleia*. Now these vesicles, wherefrom the gems take their origin, can well, we think, be considered as singularly transformed tabulæ, and thus the gemmation may be termed a vesicular one, but as a modification only of Koch's tabular gemmation.

4. Lonsdaleia virgalensis, Waagen and Wentzel, n. sp., Pl. CI, fig. 4, Pl. CXVI. fig. 2.

Corallum compound, composed of very thin, more or less cylindrical, tolerably straight corallites, rather far apart from each other, with numerous transverse wrinkles and folds and bearing a fine longitudinal striation. Calices very small, never more than 4mm. in diameter, with traces of a secondary wall. Columella very thick, even thicker than in the preceding species, occupying a little more than one-third of the entire diameter of the calices. Septa very little numerous. There are 18 to 20 primary septa and as many secondary ones; septa of a third order are never developed.

In thin sections one can observe that the primary septa generally do not reach the columella, though they approach it very nearly; only in some calices one or the other of these septa seems to touch the outer circumference of the columella, but never in contact with one of the radiating lamellæ within the latter. Between the septa there is a great number of interseptal dissepiments, which very often for a part are regularly arranged, so that a partial secondary wall is formed; this secondary wall is, however, barely ever complete, but exists generally only in a more or less extended part of the calices. Nevertheless it has some influence on the development

of the tabulæ, so that sometimes a tabulate area can be pretty clearly distinguished. The columella is very sharply circumscribed. It shows in the middle a transverse and towards its periphery some radiating lamellæ which are crossed by a concentric lamellation, a structure which is absolutely identical with that of the preceding species. In the longitudinal sections the existence of a more distinct tabulate area causes some difference from similar sections of the preceding species but otherwise both show the same features.

Locality and geological position.—There are only two specimens of this species in the Salt-range collection, which were both found in the coral-beds of the middle division of the Productus-limestone of Virgal.

Remarks.—We were a long time in doubt whether we ought to separate the present species from the preceding one, but after some consideration we found that the two specimens from Virgal were distinct from all the others not only by the considerably thinner branches, but also by some internal characters. A comparison of fig. 1*c* and fig. 4 on Pl. CI, will show these differences readily. Whilst in *Lonsd. indica* the interseptal dissepiments are arranged quite irregularly, they follow a more or less circular arrangement in the present species, so that very often a kind of secondary wall is formed. With this also a somewhat different arrangement of the tabulæ goes hand in hand, and thus we think the two species should be kept separate. The most striking difference consists always in the thinness of the branches, which never exceed 4mm.

Sub-Family: *DIAPHRAGMATOPHORA.*

Genus: AMPLEXUS, Sow.

Among the materials of corals from the Salt-range there are also a few specimens of single corals, which present nearly insurmountable difficulties in the attempt to arrive at a satisfactory determination of them.

The scarcity of specimens forbids the free use of the grindstone, and besides this, the preservation of the specimens is for the greater part so spathic that polished sections are of but little use; the description must then be brief and to a certain extent incomplete. Yet we thought it not fit to pass them over in silence, as the proposed outlines of the entire fauna of these beds would no longer be correct if such a large division of corals, specimens of which are not unfrequently met with, were not mentioned at all; thus we shall give a description of these forms as best possible according to the materials at hand.

As far as can be made out it seems that all the single corals that are preserved in the Salt-range collection belong to the genus *Amplexus*, as they possess more or less closely set tabulæ, very short septa, and a small but distinct septal fossula. A vesicular zone in the peripheral parts of the individuals is absent, but they all are covered with a distinct thick epitheca.

Two forms can be made out which are also distributed in different geological horizons. One of them is restricted to the middle division of the Productus-limestone and seems to us to be a new species to which the name of *Amplexus cristatus* will be given; the other species occurs only in the upper Productus-limestone, and seems to us identical with what has been described by Abich under the name of *Amplexus coralloides*, Sow., from the permian beds of Djoulfa, and which has been shown by Möller to be different from Sowerby's species, without, however, giving a name to it. It seems to us that this form most practically would receive the name of *Amplexus abichi*.

1. AMPLEXUS CRISTATUS, Waagen and Wentzel, n. sp. Pl. C, fig. 2.

Corallum simple, elongately conical, generally curved, fixed by its apex to foreign bodies. Surface longitudinally striated, undulating, provided at intervals with high transverse crests, on which thorn-like processes are placed. The crests do not show any regularity and never encircle the entire coral. Calix apparently deep but much worn and deteriorated by pressure, provided with very short septa. Septa not numerous, altogether, primary and secondary, not more than 28. In sections the length of the septa is about one-third of the entire diameter of the corallum. Septal fossula distinct, deep, not large, being enclosed by two longer septa and containing only one single septum. Septa connected together by septal dissepiments not far from their terminations. Space between the dissepiments and the outer wall filled by rock-matter without intercalation of a vesicular tissue. Tabulæ not very numerous, very strongly convex, flattened on the top, the tabulate area occupying the entire space of the corrallum.

The dimensions of the better preserved of the two specimens at our disposal are as follow:

Length of the entire corallum	42 mm.
Thickness at the upper extremity	19 mm.

Locality and geological position.—There are altogether not more than two specimens of this species in the Salt-range collection. One of them comes from Káfirkot, from the middle division of the Productus-limestone, the other from between Vurcha and Uchâli out of the same beds.

Remarks.—The species which is most nearly related to the present one, and which perhaps would be considered by some even identical, is *Amplexus spinosus*, Kon., from the mountain-limestone of Tournay, etc. This interesting and well-characterised species agrees with the Indian form in having the same number of septa, which are of the same length, and in its possessing thorns on the lower part of its outer surface. The difference of the two forms consists in the high thorned crests in the Indian form, and apparently also in a much deeper visceral chamber and more strongly convex tabulæ.

At all events, *Amplexus spinosus* must very probably be considered as the ancestor of *Amplexus cristatus*, which represents the former species in more recent strata.

Of other species none is known to us which could be more particularly compared.

2. Amplexus abichi, Waagen and Wentzel, n. sp.

1878. *Amplexus coralloides*, (Sow.) Abich : Fauna of Djoulfa, p. 84, pl. XI. fig. 10 (*non* Sow.).
1879. *Amplexus sp.*, Möller : Neu. Jahrb., 1879, p. 237.

There are two specimens of a not very large, rather smooth *Amplexus* in the Salt-range collection, which probably can be identified with *Amplexus coralloides*, Abich (*non* Sow.). The specimens are, however, in much less satisfactory preservation than those figured and described by Abich, and thus we have abstained from giving a figure of them. The diagnosis of the species may run as follows :

Corallum simple, elongately conical or sub-cylindrical, straight or slightly curved with a tolerably thick epitheca on its outer surface, which is longitudinally striated and shows many wrinkles of growth encircling the whole corallum. Calix apparently not very deep, with few not very strongly developed septa. Septal fossula small, and not very distinct. Septa numbering 26 to 28 at a diameter of the calix of 18mm. Length of the septa little more than one-fourth of the diameter of the calix. The septa are united towards their termination by a row of septal dissepiments. Tabulæ numerous, vaulted, largely flattened on the top, often irregular and somewhat vesicular.

The species did not apparently attain very considerable dimensions. The largest specimen figured by Abich has a diameter of 23mm. at its upper extremity and may have reached a length of about 75mm. Our Indian specimens are by far smaller, attaining a diameter of 16 and 18mm. at the upper extremity.

Locality and geological position.—Both specimens of this species in the Salt-range collection come from the upper division of the Productus-limestone; one of them was found in the Cephalopoda-bed at Jabi, the other at the limit between the upper and middle divisions at Khura.

Remarks,—There cannot be any doubt that the case has been put too strongly by Mr. Möller, when he says : These forms have not the slightest similarity with *Amplexus coralloides*, Sow. If this were in reality the case, we should not know to what form else the present species should be compared. In reality we think the species so closely related to *Amplexus coralloides*, that a separation becomes rather difficult, and the mistake of having it described as identical with Sowerby's species cannot be considered as very great.

The chief differences consist in the septa being slightly longer and somewhat less numerous than in equal-sized specimens of *Amplexus coralloides*, so that the present species can well be considered as different, but must at the same time probably be taken as a direct descendant from the lower-carboniferous species.

We know of no other form with which *amplexus abichi* could be more particularly compared.

The identity of our Indian specimens with this Armenian permian species is again of some geological interest.

Order: ALCYONARIA.

Sub-Order: HELIOPORACEA.

Family: *FISTULIPORIDÆ.*

The *Alcyonaria* have an entirely stony skeleton, not internal but covering the body to a certain extent externally; they can be divided in two groups. One of these is formed by *Tubipora* and the allied genera, which all have a stolonal gemmation; the other is typified by the genus *Heliopora*, and in this group a cœnenchymal gemmation prevails. The number of genera which, by this character, appear rather nearly related to *Heliopora*, is pretty large; two groups can be distinguished among them. The first has rather large polypites, having a more or less large number of pseudosepta; to this group the genera *Heliopora*, *Heliolites*, &c., belong; the second group has only small tabular polypites either entirely without pseudosepta or with only two of them, which is the highest number that ever occurs.

The first of these groups forms the family *Helioporidæ* of Mosley, the second the family *Fistuliporidæ*.

Thus to bring to notice the rather near relation between the two families we have created a sub-order, *Helioporacea*, for their reception.

The family *Helioporidæ* has been excellently characterized by Mosley; and Zittel has in his Handbook quoted the different genera that probably can be considered as belonging to it. Nicholson also has contributed much towards the elucidation of the family.

The case is different with the family *Fistuliporidæ*. First of all it has not been recognised to constitute a family up to the present; on the contrary, the genus *Fistulipora* was either considered to form part of the *Monticuliporidæ*, or else it was entirely removed to the *Bryozoa* and considered as only a stage of development of certain Bryozoan genera.

When we took up our studies on the *Monticuliporidæ* we had naturally to include *Fistulipora* and allied genera, as Nicholson had treated them all together, and it was from the beginning by no means evident that *Fistulipora* was so radically different from *Monticulipora* as we now must consider it to be. As the case stood we had to a certain extent to notice the characters of the *Fistuliporidæ* in the introduction to the *Monticuliporidæ*, and we there stated that the most fundamental difference between them consists in the mode of gemmation, which is in the latter an intermural one; whilst it is cœnenchymal in the former.

It has been shown by Koch and others, that cœnenchymal gemmation is characteristic of *Heliopora*, *Heliolites*, and other *Alcyonaria*, and that it does not occur in any of the *Hexacoralla* or *Rugosa*.

To get at a right understanding of the process of cœnenchymal gemmation, we must take a look at the cœnenchyma with which all these forms are provided and from which gemmation takes its origin.

It must first be remarked that the cœnenchyma in the *Helioporacea* is an organ entirely different from anything that occurs in other corals. Originally it consists entirely of parallel tubes, which are again parallel to the polypites, and every cœnenchymal tube possesses numerous tabulæ. This tubulate condition of the cœnenchymal cells, so that each of them can be followed for greater distances, and appears perfectly individualized, distinguishes the cœnenchyma of the *Helioporacea* from that occurring in other corals, as in the latter the cœnenchyma is always of a spongy nature and never composed of straight tubes, or of vesicles which have even originated in such tubes. If, as is often the case in the later stages of growth, the tubes are resolved into irregularly arranged vesicles, the tubes can no longer be followed. This is caused by an excessive growth of the tabulæ, as has been already stated by Nicholson. In such cases it must always be borne in mind that only the last layer of vesicles was occupied by living animals. The excellent explanation given by Lindström of the formation of cœnenchyma can apply only to the cœnenchyma of the *Zoantharia* but not to that of the *Alcyonaria*.

With regard to these cœnenchymal tubes the opinion has been expressed by Mosley that they were the dwellings of singularly transformed animals, so that a colony of *Heliopora* (the living form on which Mosley made his observations) was to be considered as dimorphic, as composed of two different sets of animals, of which the one, the *siphonozooids*, dwelt in the cœnenchymal tubes, whilst the others, the *autozooids*, occupied the larger calices. Leukart also is inclined, induced by the observations made on *Sarcophyton*, to concur with Mosley in this view, though the siphonozooids in *Heliopora* have neither stomach nor mesenteries, and do not even open on the surface.

Now with regard to the existence of such reduced animals the cœnenchymal gemmation opens out a very strange perspective.

In the cœnenchymal gemmation a number of these cœnenchymal tubes apparently unite to form together a new autozooid, so that several reduced individuals become blended together into a single perfect one.

The process can be very distinctly followed in recent and fossil forms and has been figured exactly by Koch (Palæontograph. 3 Ser. Vol. V.) in *Heliopora* and *Heliolites*, by Lindström in *Plasmopora*, &c. Also we have given figures representing the process Pl. CXV, figs. 5 and 6. In this process a group of cœnenchymal tubes becomes more distinctly circumscribed, slowly it affects a circular or, as the case may be, a bilobed appearance, then the walls of the single tubes, lying within the circumscribed area, become dissolved by degrees and at last the new autozooid has attained its full development.

In longitudinal sections one sees several cœnenchymal tubes with their closely set tabulæ ascending straightly, then they suddenly stop, and in their place a large tube possessing less numerous tabulæ appears.

This cœnenchymal gemmation has been studied already so often and by so many observers that there cannot be any doubt about the process itself, and the difficulty exists only with the explanation of it.

The reasons why the cœnenchymal tubes are considered to be inhabited by a distinct sort of animal are two, first, the tabulate condition of these tubes, and then their mode of augmentation. As regards the first character, it has been stated by Mosley that in *Heliopora* only the uppermost part of the colony is actually alive, and that all below the last tabula is dead, and often inhabited by parasitic animals. Now the cœnenchymal tubes develop their tabulæ independently of the large tubes, and thus it appears not improbable that they are also inhabited by independent animals. As regards the augmentation of the cœnenchymal tubes, this really appears as a kind of propagation, as occurs in fully developed corals. Generally the tubes augment by fissiparity, as has been shown and figured by Koch and recently by Nicholson and Foord; but by Mosley there has been described in *Heliopora* a mode of augmentation which comes very near "intermural gemmation." Quenstedt, however, long ago made observations in this direction; he says that the new cœnenchymal tubes appear quite in the same way as do the new corallites in *Chætetes*, and fragments could even be mistaken for each other. That intermural gemmation occurs off and on also in the cœnenchyma of fossil forms is shown by *Fistulipora eriensis*, Roming, whereby, in the corners where several cœnenchymal tubes meet, spiniforms corallites, or Acanthopores as they are now called by Nicholson, are developed, a nearly unmistakable sign of intermural gemmation. These two characters combined make it appear highly probable that the cœnenchymal tubes are really inhabited of by proper animals, which display certain functions, as the production of tabulæ and gems.

Great doubts have, however, been brought forward against Mr. Mosley's view by Lindström, the chief of which is that several of these tubes blend together to form one fully developed animal, a process which does not occur besides in the whole animal world. Though this is a point that ought to be properly worked out by zoologists, we may perhaps suggest some view which might dispense with this most extraordinary fact.

Mr. Koch has, in the *Pennatulidæ*, observed the fact that sometimes one of the *siphonozooids* is transformed into an *autozooid*. Now with this transformation a great change in size certainly goes hand in hand, and the new *autozooid* requires much more room than formerly did the *siphonozooid*. It might then well be imagined, that in reality only one of the *siphonozooids* inhabiting the cœnenchymal tubes is transformed into an *autozooid*, but to make room for the new individual thus formed, the surrounding *siphonozooids* die, and that the first sign of this beginning decay is just the thickening of the outer walls, which are destined to form together the wall of the new *autozooid*.

An observation which is also in favour of the view that the cœnenchymal tubes were inhabited by proper animals has been recorded by Dybowsky; this is that the whole colonies are in their beginning often composed of nothing but cœnenchymal cells, and only later on the larger tubes are developed. We could ourselves very often observe the same fact; and even the description of the very youngest individuals of *Heliolites* given by Linström says: Die jüngsten Individuen einer Helioliten-

Colonie, oder vielmehr der erste Polyp, der Gründer einer solchen Colonie, hat ein dütenförmiges, spitzes Polyparium. Die kleinsten, welche ich gefunden, messen 1mm. Man sieht doch schon die zwölf Septen, und *auf der Bodenseite des Polypariums breitet sich ein feinmaschiges Cœnenchyma aus.* (Richthofen's China Vol. IV p. 59.)

After having thus considered the cœnenchymal gemmation in general, we must turn again to the *Fistuliporidæ* in particular. That *Fistulipora* has a cœnenchymal gemmation is amply shown by Nicholson's figures of the typical species, *Fist. minor*, M'Coy, or, as it must now be called, *Fist. incrustans*, Phill., and by Dybowsky's figures of *Callopora;* and that this gemmation is absolutely identical with what has been described and figured of *Heliopora* and *Heliolites* is so obvious, that it needs only a look at the drawings to become convinced of the matter.

The genus *Fistulipora* only occurs sparingly in the palæozoic beds of the Salt-range, and we must rely chiefly on other genera for the particulars of the family. These genera are, however, on the whole so nearly related to *Fistulipora* proper, that what applies to them will be applicable also to *Fistulipora*.

The two genera we have to describe are *Dybowskiella*, a new genus, which will be described presently, and *Hexagonella*, also a new genus allied to *Evactinopora*, Meek and Worthen. In these genera the cœnenchymal gemmation has been followed by us in detail, and it could be observed not only in longitudinal sections, where several cœnenchymal tubes are suddenly replaced by a large tube, but also in transverse sections, where the blending together of the cœnenchymal tubes to form a new polypite could be followed step by step (Pl. CXV, figs. 5, 6), that the process is absolutely as in *Heliolites* or *Plasmopora*, and that the difference between those genera and the *Fistuliporidæ* is not a structural one, but consists only in the circumstance that the polypites are generally smaller in the *Fistuliporidæ*, and are either altogether devoid of pseudosepta, or when the latter are present they never exceed the number of two.

The similarity between *Fistulipora* and *Heliolites* is a fact that has been long since recognised, and it has been expressed very clearly by Nicholson. It often goes so far that one has been mistaken for the other, and species of *Heliolites* have been described as *Fistuliporæ* and *vice versa*. Notwithstanding this, Lindström considered the similarity as only external, and places the larger part of *Fistuliporæ* in the *Bryozoa*, thus separating them entirely from the corals. We are not prepared to assert that in every case what has been described under the name of *Fistulipora* is really a coral; but for those forms that show the cœnenchymal gemmation described above we must absolutely claim the coral nature, as this is a character so intimately connected with the nature of certain forms of corals, that a fossil which bears this character cannot possibly be anything but a coral. Thus Lindström's view can apply only to forms which have a quite different gemmation, that is to say, the gemmation that occurs in the *Bryozoa* as has been described above in the introduction to the *Monticuliporidæ*. That such forms really exist cannot be denied; but *Fistulipora incrustans*, Phill., the very type-species of the genus, does not belong to them, so we cannot but place the genus among the corals, and not among the *Bryozoa*.

Nicholson places rather great stress on the circumstance that there are no distinct pseudo septa in *Fistulipora*, and considers this as sufficient reason to separate the genus from the *Helioporidæ*, with which it is confessedly very nearly related, placing it in the *Monticuliporidæ*. Though we also think that the presence or absence of pseudosepta can well be used as a character for the distinction of families, yet we must separate the *Fistuliporidæ* from the *Monticuliporidæ* on account of the different gemmation that prevails in the two families. The *Fistuliporidæ* must be placed in the vicinity of the *Helioporidæ*, as showing the same mode of gemmation, and the *Monticuliporidæ* in the vicinity of the *Favositidæ* as agreeing in their mode of gemmation with the latter.

After having thus discussed in detail the systematic position we give to the *Fistuliporidæ* we may safely proceed in exposing the characters of the family.

The skeleton consists of a hard calcareous mass, which does not show any sign of being composed of sklerites. The several parts of it are arranged so as to form distinct walls by which larger round or oval polypites and smaller cœnenchymal cells are circumscribed. These walls show in transverse sections, as in other corals, a dark line in the middle indicating the existence of a primordial wall. In silicified specimens the dark line is replaced by a light-coloured one. Quenstedt has observed the same dark line in the middle of the walls of species of *Heliolites*, and concludes from this observation that the walls in *Heliolites* were double. On both sides of this primordial mural plate secondary thickenings of the walls are observable, but in most forms of the family these thickenings remain always very thin, only rarely they attain a certain thickness and then are distinctly seen to be composed of calcareous fibres, vertical to the surface. Such thickenings are often restricted to one side of the tubes of the polypites only.

There are two kinds of cells: the larger ones, the true polypites (which, however, never attain considerable dimensions, 2mm. being about the largest diameter they ever exhibit) show a round or oval, sometimes a bilobed, outline and only rarely contain a trace of two pseudosepta, never more, whilst generally septa are entirely absent; and the smaller cells, occupying the space between the larger ones; they are angular and form a distinct cœnenchyma, being sometimes present in great numbers.

There is no direct communication between the larger and the smaller cells, though in some forms of *Dybowskiella*, when they are not very well preserved, the mistake might arise that such a communication existed.

Sometimes the cells of the cœnenchyma appear somewhat incomplete, not being perfectly circumscribed on all sides. This is probably a feature that depends upon preservation solely, and is of no palæontological importance.

In longitudinal sections the cells of the larger polypites are tubular and show distant, mostly complete, tabulæ, to which sometimes a vesicular tissue is added. Also the cœnenchymal cells are mostly tubular, with a great many tabulæ, which are very closely set and sometimes strongly vaulted. Often the tabulæ are developed to such an excessive extent, that the walls of the tubes are quite obliterated, and each chamber, partitioned off by a tabula, is transformed into a vesicle.

All the forms belonging to this family have a cœnenchymal gemmation.

The number of genera that can be placed in the present family is not very great, nevertheless some sub-families can be distinguished very conveniently.

I. Sub-family: *CALLOPORINÆ.*

The polypites are small, tubular, with simple tabulæ, devoid of pseudosepta and of so-called folds as described by Nicholson and Foord.

1. CALLOPORA, Hall, 1852: Pal. of New York, vol. II, p. 144; Dybowski: Die Chætet. des ostbalt. Silur, p. 106, 1877.—At the beginning we considered this genus identical with *Fistulipora*, McCoy, following in this respect Nicholson's own indications. But since that author has changed his views as to *Fistulipora*, this latter genus cannot be considered any longer as identical with *Callopora*. We must take as correct the observations made by Dybowsky, who has proved in every case a very fair observer, and must accept the view that the silurian species described by him were without "folds." Whether Dybowski's identification of his silurian forms with *Callopora*, Hall, was correct, is another question, which cannot be solved for the moment. We therefore have quoted also Dybowski's work. Colonies arborescent or incrusting. Silurian.

2. *?* EVACTINOPORA, Meek and Worthen, 1868: Geological Survey of Illinois vol. III, p. 501.—Colonies bilateral, with polypites rising from a median calcareous lamella, forming lamellar expansions which are arranged regularly around an imaginary axis, thus assuming star-like figures. Carboniferous: ? Permian.

3. HEXAGONELLA, Waagen and Wentzel, n. gen.—Like *Evactinopora*, but the lamellar expansions never regularly arranged, often forming flattened branches; on the surface the polypites distributed in generally hexagonal spaces, which are divided from each other by more or less high ridges and bear mostly maculæ in the middle.

II. Sub-Family: *PRASOPORINÆ.*

Polypites small, tubular, with tabulæ partly transformed into a kind of vesicular tissue, or single vesicles along the walls of the polypites. No pseudosepta developed.

4. PRASOPORA, Nich. and Eth. jun., 1877: Ann. and Mag. Nat. Hist., ser. IV, vol. XX, p. 388.—Corallum concavo-convex or discoid, sometimes free with a concentrically striated basal epitheca, more rarely attached by its base to some foreign object. Silurian.

III. Sub-Family: *FISTULIPORINÆ.*

Polypites small, tubular, with simple tabulæ, provided with a thickening or callosity on one side of the tube, which at both ends is sometimes developed into two distinct pseudosepta, whereby the tubes get a bilobed appearance in transverse sections.

5. FISTULIPORA, McCoy (emend. Nicholson and Foord), 1852: Ann. and Mag. Nat. Hist., ser. 2, vol. III, p. 130; 1885, Nicholson and Foord: Ann. and Mag. Nat.

Hist., ser. V, vol. 16, p. 496.—Polypites with a little prominent callosity on one side of the tube, forming the "folds" described by Nicholson and Foord. Colonies incrusting, rarely arborescent. Silurian to carboniferous.

6. DYBOWSKIELLA, Waagen and Wentzel, n. gen.—Polypites with two strongly developed pseudosepta projecting into the interior of the tube. Colonies arborescent, polypites never arranged bilaterally on a median plane, sometimes incrusting. Devonian to permian.

With these genera the number that we can with safety assign to the family is ended. A number of other genera have, however, been described and studied in detail by Nicholson and Dybowsky, which could find no place in the list, as we are by no means certain as to their systematic position. In all these the cœnenchymal gemmation, the only safe criterion for the discernment of the systematic position of these little things, could not be made out from existing drawings, and we had neither time nor materials to make studies in that direction. Nevertheless there are in many cases some characters observable which make a position among the corals very doubtful, and rather suggest the thought that they should be considered as *Bryozoa*. Such forms are *Trematopora*, Hall, as described by Dybowsky, and *Dittopora*, Dybowsky. In these forms the "Wandröhrchen," as they are called by Dybowsky, can well be compared with the "interstitial ribs" as described by Smith in *Discoporella*, &c. But also in other respects these colonies are more like *Bryozoa* than like corals. In the young state, that is, in the central parts of the colonies, there is no cœnenchyma present; this is developed only later on, or is entirely replaced by a compact ground-substance. This shows that in these forms the cœnenchyma is not morphologically the same thing as in *Fistulipora* for instance, and that it is probably to be considered identical with the interstitial substance of the *Bryozoa* that often fills the spaces between the single animals, and appears only in old colonies, when the single animals follow different directions. In *Dittopora* again there is sometimes the appearance as if two different sets of animals were present, distributed in different zones. This appearance, however, seems to be brought about only by the circumstance, that in some of these zones the animals are more closely packed together than in others, and therefore they appear angular and without any interstitial substance.

The same reasons cause us also to consider *Stellipora*, Hall, or *Constellaria*, Dana, as a Bryozoan rather than as a coral; their tubes are united in little groups, in which a cœnenchyma is entirely wanting. These little groups project above a general mass of interstitial substance, which is made up of the so-called cœnenchyma. But, as has been stated above, a definite judgment on these forms can only be passed after the mode of gemmation is studied in detail.

In the Salt-range only two genera belonging to the family *Fistuliporidæ* have been detected up to the present, *Hexagonella* and *Dybowskiella;* both, however, furnish rather numerous species and a multitude of specimens. To these must yet be added one species of *Fistulipora* proper, according to the new definition of the genus given by Nicholson and Foord.

Sub-Family: *CALLOPORINÆ.*

Genus: HEXAGONELLA, Waagen and Wentzel, n. gen.

The corallum consists of laminar expansions, which sometimes are reduced to flattened dichotomous branches. Each lamina or branch is divided along its middle by a thin calcareous lamella, on both sides of which the polypites are situated. This lamella is made up of the somewhat thickened basal lamellæ of the first layer of cœnenchyma and polypites. From this lamella the polypites rise vertically (to the plane of the lamella). It cannot be exactly made out whether the first layer is not entirely made up of cœnenchymal cells; soon, however, some of these cells unite to form larger polypites. These polypites open on both surfaces of the lamellar expansions with round or oval calices, separated from each other by a space of cœnenchyma which is either equal to or double the diameter of the polypites. Larger spaces, entirely made up of cœnenchyma, form maculæ. Cœnenchymal cells always polygonal. In sections vertical to the planes of the corallum one sees that the tabulæ are often all on the same level, and thus a somewhat laminar structure of the corallum is brought about. Another cause of an apparently laminar structure is the partial silification of the specimens.

The surface of the corallum is provided with more or less prominent straight ridges, which mark off polygonal, mostly hexagonal, spaces, within which the calices of the polypites are often somewhat radially arranged. Maculæ are generally found in the middle of these spaces. These ridges are a rather superficial structure and do not reach far inside the corallum, so that they are easily rubbed off and destroyed by weathering.

We are by no means quite certain that the present genus is always a well distinguishable one; the genus *Evactinopora* of Meek and Worthen is very nearly related, and might even perhaps be partly identical. These doubts have been greatly augmented after the description by Hudleston of some species of *Evactinopora* from Australia which can partly be considered as nearly identical with the Indian forms. Nevertheless the original description of the genus *Evactinopora* is so unsatisfactory—one cannot even make out whether there exists a cœnenchyma or not, and the authors themselves have considered it as a Bryozoan—that the identification of other specimens with this American genus becomes rather problematical. It is very different with Hudleston's descriptions of the Australian specimens. The character on which the greatest stress has been laid by Meek and Worthen in the description of *Evactinopora*—the union of the laminar expansions in an imaginary axis, so that star-formed bodies are produced—is repeated in the Australian specimens, at least to a certain extent by some forms, and these might rightly be identified with *Evactinopora;* but others are ramified and do not fit well into Meek's genus; they rather should be removed to our *Hexagonella.* All of these, however, are shown by Hudleston to possess large and small tubes, of which the former are sparingly tabulated, whilst the latter show many tabulæ.

In thus quoting *Evactinopora* among the genera belonging to the *Calloporinæ* we rely chiefly on Mr. Hudleston's observations.

With regard to the network of hexagonal meshes that has been described above as being observable in the species of *Hexagonella* it is perhaps of less systematic importance. Nevertheless it is a strange fact that all the forms occurring in the Salt-range bear this character. A similar sculpture has been observed by Dybowsky in a species of *Dianulites*, and Eichwald has made a proper genus of it, "*Hexaporites*." As in this case this sculpture is the only distinguishing character; it is barely sufficient to found a genus upon.

The prominent ridges of which the meshes are formed are made up in the Indian forms by parts of the walls of the adjoining cœnenchymal tubes, which together form a straight line of calcareous substance. As this singular disposition of the walls only takes place in the superficial portions of the colony, the ridges cannot be followed far inside, and sections taken a little below the surface either show nothing of the ridges or only traces of them, Pl. CVII, fig. 3*a*, 3*b*. This is the cause why these ridges are so easily lost in weathered or otherwise deteriorated specimens.

Besides *Evactinopora* only the genus *Coscinium* can come into consideration for close comparison with the forms here under description. The species originally described under the name are most probably *Bryozoa* and not at all related to the *Fistuliporidæ*, but there has at least one species been described by Trautschold, *Coscinium sellæforme*, Trautsch., which, according to the description and the not very satisfactory drawings, is probably a *Fistuliporid* and not a *Bryozoon*. From our Indian materials it is distinguishable by a different mode of growth and the absence of an hexagonal network of prominent ridges on the surface.

The genus *Hexagonella* is represented in India by three species, one of which very nearly agrees with *Evactinop. dendroidea* of Hudleston, which in fact is also probably a *Hexagonella*. Nevertheless none of the Indian forms can be directly united with any hitherto described. Two of the species are characteristic of the middle division of the Productus-limestone, the third has its chief distribution in the middle division but extends also into the upper division.

1. Hexagonella ramosa, Waagen & Wentzel, n. sp., Pl. CVI, figs. 3, 4; Pl. CVII.

Corallum consisting generally of flattened branches, which sometimes, however, become nearly cylindrical; the branches are repeatedly dichotomous, and thus the whole corallum becomes more or less arborescent. The centre of each branch is occupied by a broad calcareous lamella, from which the polypites diverge bilaterally. This lamella does not always retain the same direction, but is very often subject to a kind of torsion, which is followed also by the branches. Surface of the branches, when well preserved, provided with slightly projecting straight shelly ridges, forming a somewhat hexagonal network. In the spaces between the ridges the calices are situated. They are generally surrounded by a slightly projecting

margin; are of a round or somewhat oval shape, and separated from each other generally by a space as broad or a little broader than their own diameter. Within the hexagonal spaces the calices are mostly arranged in somewhat irregular radial rows, which are vertical to the sides of the hexagons. In the middle of these spaces there occur more or less large maculæ, or smooth spaces, occupied solely by cœnenchyma. The spaces between the polypites are occupied by cœnenchymal cells, of which two to three rows between two polypites can be counted. The cœnenchymal cells are always polygonal and very considerably smaller than the polypites. They are often irregularly penetrated by boring animals.

In sections parallel to the axis of the branches the polypites are seen as comparatively wide tubes, provided with very scarce tabulæ. In reality, however, they are very small, so small that within the length of 1mm. three tubes with the intervening cœnenchyma can be counted. The spaces between the polypites are occupied by cœnenchymal tubes, the walls of which often show zig-zag bends. They are provided with very numerous tabulæ, many of which are often on the same level, thus causing a kind of lamination, parallel to the surface of the corallum. The cœnenchymal gemmation can in most sections be very clearly observed. How large the species may grow we cannot judge, as only fragments of branches are at our disposal. The largest fragment we have seen has a longer diameter of 28mm. and a smaller one of 13mm., a proof that the branches have attained considerable dimensions.

Locality and geological position.—The species has its chief development in the middle division of the Productus-limestone, but extends also not rarely into the upper division. In the middle division it has been found at Khura (3 sp.), between Vurcha and Uchâli (6 sp.), at Swás (3 sp.), at Morah (2 sp.), at Musakheyl (3 sp.), at Kálabágh (1 sp.) and at Bilot (1 sp.).

In the upper division it has been detected at Khura (2 sp.) and in the Cephalopoda-bed at Jabi (6 sp.) and Chidru (2 sp.).

From this list, it appears that the species is a very common one.

Remarks.—There are but very few forms with which the present species can at all be compared. The form which seems to be most nearly related to it is *Hexagonella dendroidea*, Hudleston sp., from Australia. That this species should be considered as a *Hexagonella* rather than as an *Evactinopora* has been stated already in the introduction to the genus. From the description, as well as from the excellent drawings given by Hudleston, this fact is scarcely doubtful; so there cannot be any differences of a generic nature between the form here under consideration and the Australian fossil. The specific differences even do not seem to be very great. The Australian form seems to have in general cylindrical branches, and only exceptionally do these become flattened; whilst in the Indian form just the reverse is the case. The Australian fossil is apparently also much more robust, and the calices seem to be larger, if the drawings are correct, as only two pores occur within the distance of 1mm. Last not least the hexagonal network of prominent ridges, so conspicuous in all our specimens, except in the very worst ones, is completely absent

in the Australian species, though this is, according to Hudleston's indications, very well preserved.

Thus it seems that the Indian species is different from the Australian one, though both are generically identical.

Of other species there is apparently none to which the present one could be more particularly compared.

The preservation of the Indian specimens is, we regret to say, not very favourable for making microscopical sections on account of the infiltration of great masses of silica which obscure the more minute features of the tissue. We therefore were not in a position to give a better figure of a longitudinal section than that drawn, Pl. CVII, fig 3*c*.

2. HEXAGONELLA TORTUOSA, Waagen & Wentzel n. sp., Pl. CVIII, figs. 1, 3, 4, 5.

Corallum lamellar, forming large, branching expansions, which bend in all directions, dividing and anastomosing quite irregularly, but being exposed generally only in sections, and the surface nearly always covered by rock-matter. The lamellar expansions are divided along the middle line by a thin calcareous lamella from which the polypites extend bilaterally. Both surfaces covered by an irregular network of prominent angular ridges surrounding rather deeply hollowed spaces, in which the calices are situated. Maculæ occur only off and on in the middle of these spaces. In transverse fractures the ridges form prominent edges, whereby the whole body of the corallum appears as if fringed on both sides. The calices are circular or slightly oval, showing no regular distribution whatever. They are very small, and there are about 3 within the space of 1mm. They are about their own diameter distant from each other. Between them a cœnenchyma is developed which consists of fine angular meshes. In transverse, or, as one may also call them, longitudinal sections, the polypites appear as somewhat bending tubes, generally separated from each other by three rows of cœnenchymal cells. The tabulæ are straight and not very scarce in the polypites, but never closely set. In the cœnenchymal tissue the walls of the tubes generally show zig-zag bends, the tabulæ are very numerous, and the parts so tabulated off present an hexagonal outline. The augmentation of the cœnenchymal tubes by fissiparity can be very distinctly observed as well as the cœnenchymal gemmation that obtains in the augmentation of the polypites. The present species is, however, like the preceding one, not very favourably preserved for making thin sections, as it is nearly always partly silicified, which, on the one hand, impedes the preparation of good slides, and on the other interferes with the clearness of the pictures. The preparation represented on Pl. CVIII, fig. 1*c*, is, however, on the whole satisfactory.

As to the size of the species nothing can be said, as only fragments are accessible to our observation; it seems, however, that it grew to considerable dimensions.

Locality and geological position.—The present species has as yet not been detected in the Salt-range proper; all the materials of it were collected by Mr. Wynne in the trans-Indus continuation of the range. It seems to occur there in the

thick coral limestones of the middle division of the Productus-limestone. The specimens which have served for description came partly from Bilot, partly from Gulámi. There are altogether four specimens.

Remarks.—There have been described, as far as we are aware, no species, with which the present one could be compared more in particular. From *Hexagonella ramosa*, described above, it is distinct by its different mode of growth and the more irregular network that it bears on both surfaces.

3. Hexagonella lævigata, Waagen & Wentzel, n. sp., Pl. CVIII, fig. 2; Pl. CXV, fig. 5.

Corallum lamelliform, forming straight leaf-shaped expansions of moderate size. Surface smooth, with a network of very faint lines, forming hexagons, within which the calices of the polypites are irregularly distributed. These lines do not project as angular ridges, but are on a level with the remainder of the surface of the corallum. At some places the surface shows fine wrinkles. Calices very small, about three within the distance of 1mm., distant from each other generally a little more than their own diameter. Shape of the calices round or oval, often, when they are still in the state of development, with two lateral projections, and then somewhat resembling the calices of *Dybowskiella*, which will be described presently. When fully developed often rather irregular in shape, but never angular. The cœnenchymal cells are very much smaller, rather unequal in size, and always angular. There are no spaces in which the cœnenchyma alone would predominate, and thus there are also no maculæ.

In transverse sections the polypites appear as comparatively wide tubes in which tabulæ are rather scarce. In the cœnenchymal tubes the walls are mostly geniculated, the tabulæ very numerous, and there are generally two to three such tubes between two polypites. As in other species of the genus so also in this one the polypites are arranged symmetrically on both sides of a thin, median, calcareous lamella.

The cœnenchymal gemmation can in this species be yet more clearly made out than in the two preceding ones, the preservation being somewhat more favourable. Sections parallel to the surface but not far from the median lamella show this gemmation in an excellent manner. Fig. 5 on Pl. CXV represents several polypites in different states of development. The median one with three sub-divisions in its interior is the youngest of all: the walls of the cœnenchymal tubes of which the new polypite has been formed are not yet re-absorbed. Next in age come the four upper polypites and one below: in these the re-absorption of the walls of the cœnenchymal tubes, which originally existed in this place, has been nearly completed, and there remain mostly two small lateral projections, though the process can also take place in a different manner, as is shown by the polypite situated in the middle of the upper part of the figure. The remaining three polypites, two on the lower part and one in the middle, have nearly completed their development. The walls of the cœnenchymal tubes have already been entirely re-absorbed, but the outline of

the polypites is not yet quite regular. How typically all this agrees with what has been described and figured of *Heliolites* appears on a first glance when comparing the figures.

What size the species may have attained cannot be indicated, as no complete specimen is at our disposal. The thickness of the lamellæ varies greatly, some of them attaining a thickness of more than 5mm., whilst others are not thicker than between 2mm. and 3mm.

Locality and geological position.—Like the preceding species the present one also has been found up to the present only in the trans-Indus continuation of the Salt-range. There are only three specimens, which were all collected by Mr. Wynne in the coral beds of the middle division of the Productus-limestone. One of them came from Gulámi, the other two from Bilot.

Remarks.—To a casual observer the present species might appear to have a striking resemblance to what has been described by Trautschold from the upper carboniferous limestone of Miatchkowa under the name of *Coscinium sellæforme*. On a closer comparison, however, one finds that though on the whole a certain resemblance cannot be denied, yet there are considerable discrepancies. Both species agree in the circumstances that they form lamellar expansions composed of two layers of polypites, and that they possess a smooth surface. In the Indian form, however, a faint hexagonal network exists, which is absent in the form from Maitchkowa, and in the latter the cœnenchyma is also by far more plentiful. According to Trautschold's indication there are at least six rows of cœnenchymal cells between two polypites, whilst there are only three in *Hexagonella lævigata*. Though thus *Coscinium sellæforme* may belong to the genus *Hexagonella* yet it is a species certainly different from our *Hex. lævigata*.

From *Hexagonella tortuosa* the present species differs by the absence of prominent ridges on the surface of the corallum, by the absence of maculæ, and the more regular mode of growth.

There is apparently no other species with which the present one could be compared.

Sub-family: *FISTULIPORINÆ*.

Genus: DYBOWSKIELLA, Waagen and Wentzel, n. gen.[1]

The corallum always consists in the beginning of incrustations covering foreign bodies. This state is, however, generally only transitory, and soon the corallum becomes elevated and by-and-by forms massive stems, which can attain a thickness of 60mm. and a height of 150mm., branching irregularly in all directions. But not only in the beginning do these forms incrust foreign bodies, but also during their growth living and dead shells are incrusted, and thus one often finds hollows in the interior of these corals, which either were filled originally with soft bodies, or in which the remains of shell-bearing animals are still found, as species of *Strophalosia*,

[1] We change the name of *Dybowskia*, given by us to these forms on page 771 of the present work, into *Dybowskiella*, after having learnt that the name *Dybowskia* has been already applied to a genus of recent Mollusks.

of *Streptorhynchus*, of *Richthofenia*, &c. Some species, however, never form branching stems but always appear as thin crusts.

The surface is covered by numerous small calices, between which cœnenchyma is more or less abundantly developed. Maculæ are generally present, but monticules are only exceptionally developed.

The calices are either round and funnel-shaped or flat and bilobed. Sometimes they are slightly projecting and separated from each other by furrows.

In thin sections it appears that the polypites are provided with two strongly projecting septa, extending along the entire length of the polypites and producing the bilobed appearance of the calices. Sometimes they stop short of the mouth and thus the round calices are produced.

The cœnenchymal cells are always polygonal in tangential sections. They generally do not open on the surface but are closed by a thin calcareous lid. It is, however, very difficult to say whether this is caused solely by preservation or whether it is an original feature.

In longitudinal sections the tubes of the polypites are provided with rather distant, straight, complete tabulæ; the cœnenchymal tubes on the contrary have vaulted tabulæ in very great numbers.

The most characteristic feature of the present genus is the existence of the two septa which are very conspicuous in all the species. It cannot be denied that forms with bilobed or trilobed apertures have been known already for a considerable time, but it had not been recognised that the projecting shell parts producing the bilobed appearance of the apertures were to be considered in reality as septa-like organs. Such species have been described partly as *Alveolites*, partly as *Fistuliporæ*, by Rominger, Schlüter, and Dybowsky. In the paper containing his description, the latter expresses already the opinion that these processes had to be considered as septa; nevertheless he did not distinguish between *Fistulipora* and the species under his notice, but called the species *Fistulipora lahnseni*.

That we have really to deal here with septa, which extend through the whole length of the polypites, is demonstrated clearly, for instance, by our fig. 3 on Pl. CII, where the polypite to the left is cut just at the place where the two septa extend from both sides into the interior of the tube, and are distinguishable as thin shelly lamellæ running along both sides of the tube. The presence of septa is, however, a fact of such importance, that the forms possessing them must certainly be separated at least generically from those without them. Thus also *Fistulipora lahnseni*, Dyb., cannot remain in the genus *Fistulipora*, but has to be removed to our present genus, *Dybowskiella*.

The circumstance, however, that this species was originally described as a *Fistulipora* is already sufficient proof how nearly the present genus is related to *Fistulipora*. In fact, on a closer examination one finds that *Dybowskiella* is in all respects identical with *Fistulipora*, except in the existence of these septa. How strangely the tubes of the polypites are transformed by these septa is shown by a look at any of our plates. It often appears as if the wall of the tube were made up of two parts

which do not entirely meet each other, but leave a little space free, by which the tube would communicate with the adjacent cœnenchymal cells: this appearance is figured Pl. CII, fig. 2 *a*, *c*, &c. That such openings do not exist in reality, but that this appearance is probably only brought about by a singular mode of preservation, is shown by other figures as Pl. CIV, fig. 6, Pl. CIII, fig. 1*d*, &c. Also otherwise the mode of preservation influences much the appearance of the tubes, which appearance, however, seems to depend also partly upon the age of the colonies. In young colonies apparently the walls of the tubes are simple, forming a single dark line. In somewhat older tubes secondary thickenings of the walls appear; these are first restricted to the smaller lobe of the tube connecting the two septa (Pl. CII, fig. 2*a*,); later on also the other parts of the tubes show such thickenings, which always exhibit a fine radially striated structure, Pl. CIV, fig. 1*b*. How far these thickenings were originally present, or have been caused by preservation only, is very difficult to decide.

The occurrence of two septa within these polypites is not quite without interest with regard to Lacaze Duthier's observations on the embryology of the *Cœlenterata*, in which it is shown that the young of some of the *Actinia* and *Madreporaria* first develop two septa, which are situated exactly like the septa in the polypites of *Dybowskiella*. Though the latter genus belongs to the *Alcyonaria* yet this point may just as well not be lost sight of, as perhaps in the future it might be proved that *Dybowskiella* is a persistent juvenile state or a case of atavism.

That the position of the genus *Dybowskiella* in the *Alcyonaria* is the right one cannot well be doubted, considering the mode of gemmation prevailing in the genus. In every longitudinal section it can be seen how the polypites develop out of several cœnenchymal tubes; also in transverse sections this can sometimes be observed. We have figured Pl. CIV, fig. 2*c*, a thin slide in which the process of formation of polypites can be well distinguished, and in Pl. CXV, fig. 6, we see the process of reabsorption of the cœnenchymal walls going on within the newly formed polypite.

The question of the relation of *Dybowskiella* to *Fistulipora* has been placed in a new light by Nicholson's most recent paper on the genus *Fistulipora*. We must confess that it would have saved us an enormous amount of trouble had Nicholson's former figures of *Fistulipora minor*, now *Fistulipora muscosa*, shown any traces of the "folds" that are now stated to exist in all the species of *Fistulipora*. These folds, or more properly speaking, one-sided thickenings of the walls of the tubes, are the beginnings of the bilobed development of the tubes of the polypites, as is exhibited in an extreme manner in *Dybowskiella*. The explanation of this feature that has been suggested by Mosley and Howes is of the utmost importance, and throws also some light on the circumstance, that in other forms of the *Fistuliporidæ*, as in *Hexagonella* described above, the existence of a certain propensity to assume a bilobed appearance of the polypites cannot be denied.

From Nicholson's and Foord's definition of the genus *Fistulipora* it would seem as if there were no difference between that genus and *Dybowskiella*. It appears to us, however, that there is some difference between a one-sided thickening of the tube, causing barely any prominence to be formed on the interior of the tubes, and the exist-

ence of two well-developed far projecting pseudosepta such as exist in *Dybowskiella*. If one looks through the figures accompanying Nicholson and Foord's paper on *Fistulipora*, it is very easy to make a distinction between those forms which in reality must be included in the genus *Fistulipora*, and some others that must be considered as belonging to *Dybowskiella*. To the first must be assigned all the species described in that paper, with the exception of two, *Fist. utriculus*, Roming., and *Fist. trifoliata.*, Schlüt., which on a first glance can be recognised as forming part of the genus *Dybowskiella*. It is perhaps true that the limits between the two genera cannot be easily drawn, as some transitional forms will probably exist, but then this is the general rule obtaining in palæontology. The designation of a certain form to one or the other, of allied genera is always a matter of tact and taste, as the existence of a genus, though perhaps founded in nature by descent, cannot be established in the minds of scientists except on a certain sum of variable characters. The variability of the characters already forbids the exact circumscription of any genus, and thus it is absolutely impossible that no transitional forms should exist.

This is also the case in the two genera, *Fistulipora* and *Dybowskiella*. There is, on the one hand, a great number of forms which have developed no pseudosepta, though rudiments may sometimes exist, and there is, on the other hand, a great number of forms in which distinct pseudosepta are present, for the one the name *Fistulipora*, for the other the name *Dybowskiella*, may be used, and everybody will know what is meant by the name, and this is what is chiefly required for the moment. Before we can found genera on unquestionably established descendental grounds there will yet elapse a good deal of time, if we ever shall arrive at such a point.

Nicholson and Foord state the fact, that in well-preserved specimens the thickened part of the tubes project slightly above the general surface of the corallum in the species of *Fistulipora*, and thus forms a kind of lid. We could not observe anything similar in our specimens of *Dybowskiella*. The specimens were probably not sufficiently well preserved.

The name *Dybowskia* was applied by us already a year ago in the introduction to the *Bryozoa* (*supra*, p. 771), and it was then stated that the forms belonging to the genus possessed two septa, a fact that has been overlooked by Messrs. Nicholson and Foord.

In the Salt-range the genus is very plentifully represented, but the species are new and cannot be identified with any hitherto described. It is chiefly the number of individuals that is so great, the number of species does not exceed two. These are more or less nearly related to *Dybowskiella lahnseni*, Dyb., from permian beds of Russia.

All the species occur in the middle and upper divisions of the Productus-limestone; none has been found up to the present in the lower division.

1. Dybowskiella grandis, Waagen & Wentzel n. gen. et sp., Pl. CII; Pl. CIII; Pl. CIV, figs. 1-4, 7; Pl. CVI, fig. 7; CXV, fig. 6.

1863. *Alveolites septosa ?* (Flem.), Koninck: Quarterly Journ. Geol. Soc. Lond., Vol. XIX, page. 4, pl. II, fig. 1.
„ „ (Flem.), Koninck: Foss. paléoz. de l' Inde, p. 22, pl. II, fig. 1.

Corallum massive, forming thick cylindrical stems and branches, which frequently and quite irregularly divide, becoming thus arborescent. Height of the

entire corallum up to 200mm., thickness of the stems and branches up to 60 or 70mm., but very often thinner.

Surface of the corallum generally smooth, only exceptionally, when strongly weathered, with monticules, which are very irregularly distributed. Maculæ generally present.

Calices mostly slightly elevated, sometimes separated from each other by furrows, which form an angular network. Always very small, barely more than 0·4 mm. in diameter, whilst the distance between two calices is considerably smaller. There are generally two calices within a length of 1mm. Almost always the bilobed nature of the polypites can be recognised also in the calices, where the two septa are very well distinguishable. Only in strongly weathered specimens, such as have been figured by Koninck, and are represented on our Pl. CIV, fig. 4, the calices appear sometimes deeply funnel-shaped and nearly circular.

Cœnenchymal cells angular, and very considerably smaller than the calices. There are generally not more than one or two rows of cœnenchymal cells between two calices, only in the maculæ larger masses of cells are united together.

In tangential sections the walls of the cœnenchymal cells often appear incomplete, but this is probably caused solely by a singular mode of preservation.

In transverse sections, vertical to the surface of the branches, the polypites appear as comparatively wide tubes, with not very numerous complete and mostly straight tabulæ. The cœnenchymal tubes are much narrower, with extremely numerous vaulted tabulæ and geniculated walls.

It can be very well observed that the cœnenchymal tubes augment by fissiparity and the polypites by cœnenchymal gemmation.

Very often it can be observed, that the colonies are interrupted in their growth, and new colonies grow on them quite independently, so that several layers are observable, one above the other.

In the young state the species is always incrusting, and selects chiefly bodies which are elongated or acutely conical, as the larger valve of *Richthofenia*, of *Streptorhynchus*, &c., or even soft bodies. As has been stated in the introduction to the genus, foreign bodies are also incrusted during the progress of growth. The specimen figured Pl. CII, fig. 1 seemed to form one compact mass, but when chipping off some fragments for the preparation of slices, we suddenly came upon the large cavity represented in the figure. This cavity was probably originally occupied by some soft body. One of the most strange incrustations is represented by the specimen figured Pl. CIII, fig. 1. It is pierced by several irregularly bending holes, which very probably served for the dwelling of some Annelid. The head of those animals certainly projected above the surface of the coral, and its tentacles caused a whirling current of water which was not without effect upon the animals around. They deviated from their straight direction and followed the direction of the current to a certain extent, so that they now appear as if spirally arranged.

Locality and geological position.—This is the commonest species of the genus and is found as frequently in the middle division of the Productus-limestone as in the upper division. In this latter position the species has been collected

in the Cephalopoda-bed at Jabi (3 sp.) and in the same bed at Chidru (2 sp.), in the mountains east of Katwáhi (2 sp.), and at the base of the upper division at Khura (1 sp.).

In the middle division it has been found at Vurcha (3 sp.), on the road between Vurcha and Uchâli (1 sp.), at Morah (1 sp.), at Khura (1 sp.), and at Káfirkot (1 sp.).

Remarks.—The present species can be compared to two forms that have been previously described. One of them has been comprised by Dybowski under the name of *Fistulipora lahnseni*, the other has been described by Beyrich in the genus *Alveolites*.

Dybowski has described, under the name of *Fist. lahnseni*, two forms, one which grows in lamellæ and another which has been found to form dichotomous stems of the thickness of 10 to 12mm. It seems to us that the two cannot possibly belong to one and the same species; as the differences in the microscopical structure is generally very small in all these fossils, the different species must chiefly be distinguished according to the different mode of growth assumed by the different colonies. The name *Dybowskiella lahnseni*, Dyb. sp., must be restricted to the lamellose forms, whilst the arborescent ones must receive a new name. It is to this arborescent form that our *Dyb. grandis* seems to be most nearly related, and we even are not quite certain whether the two must not in reality be considered identical. It is true our Indian fossil attains generally by far more considerable dimensions, but if this is the only difference, it can barely be considered sufficient for the distinction of a proper species. So long, however, as detailed figures and descriptions of the Russian fossil are not forthcoming nothing can be decided as to the identity of our *Dybowskiella grandis* and the Russian permian species.

The other form that must be compared is *Alveolites mackloti*, Beyrich, from Timor. The calices of this species are not dissimilar to those of the present species, but one can say no more of the matter. It is not known whether a cœnenchyma exists or not, and thus comparison is fruitless.

A species that perhaps belongs to the present genus is *Fist. incrassata*, Nich., but as a species it cannot be compared to the present one as it grows in lamellar crusts.

2. Dybowskiella expansa, Waagen and Wentzel, n. gen. et. sp., Pl. CIV, figs. 5, 6, 8.

Corallum forming flattened branches or lamellar expansions, and on the whole very irregular in its growth. Size apparently much less considerable than in the preceding species but not exactly known, as only fragments are available. Surface smooth, without monticules. Maculæ of very rare occurrence. Calices slightly projecting, separated from each other by shallow furrows, somewhat smaller than in the preceding species, of a diameter of about 0·3mm., often very closely arranged so that there are frequently three calices within the distance of 1mm. The shape of the calices is either distinctly bilobed or nearly circular. Spaces between the calices

occupied by angular cœnenchymal cells, which are however barely distinguishable on the surface.

In tangential sections the polypites show very clearly the two septa, except when they are not yet fully developed. The polypites are often so closely arranged, that no cœnenchyma intervenes, and the shape of the polypites is greatly altered. This is, however, only partly the case; in other parts of the same individual sometimes the cœnenchyma is developed as in the preceding species. Transverse sections show the same characters as are exhibited by other forms and have been described already in the introduction to the genus.

If the species appears in lamellar expansions, the lamellæ attain a rather considerable thickness, at least 4 to 5mm., and seem to bear calices only on one side. In the flattened branches the calices cover the entire surface, and there is no middle line from which the polypites would start, but a middle zone as in cylindrical branches. The branches are, however, mostly drawn out on one side into wing-like expansions, forming lamellæ, but they are mostly broken off. These lamellæ also bear calices only on one side. The largest branching specimen is 37mm. in its larger diameter, and only 16mm. in the opposite direction. Its length is 61mm.

Locality and geological position.—The present species is a rather rare one and has also a rather limited geological range. It begins in the uppermost layers of the middle Productus-limestone, in which position it has been found in the section at Khura (1 sp.). It is more numerous in the lowest beds of the upper division, where it has been collected in the same section at Khura (3 sp.); another specimen was found by Mr. Wynne at Bilot.

Remarks.—The species here under consideration is very nearly related to the preceding one, and in microscopical structure there is no great difference to be found, except perhaps the more reduced development of the cœnenchyma. The mode of growth is, however, entirely different. Whilst *Dyb. grandis*, W. & W., forms always cylindrical or branching masses in which the branches are again approximately so, and the young individuals are always parasitical, incrusting foreign bodies, in the present species the branches are always flattened and tortuous, and the young individuals are always lamellar, not parasitical, only changing slowly into the branching form. This entirely different mode of growth is, we think, sufficient for the distinction of a proper species and thus we introduce a new name for it.

There has no form been described up to the present with which our *Dyb. expansa* could be compared more in particular, as *Dyb., lahnseni*, Dyb. sp., which is also lamellar, has by far thinner lamellæ.

Genus: FISTULIPORA, McCoy.

It is only after the new definition of the genus *Fistulipora* by Nicholson and Foord, that we must admit the existence of a species belonging to it in the Salt-range. The descriptions of the genus in the former publications of Mr. Nicholson gave no hint as to the existence in this genus of organs more or less similar to the

pseudosepta occurring in *Dybowskiella*, and thus nobody had an idea of the real characters of the genus. We had therefore not considered any of the species occurring in the Salt-range as belonging to *Fistulipora* but had them all placed in *Dybowskiella*. Now the case is different. The genus must now be defined in the following manner.

Corallum consisting of two sets of tubes, smaller ones that occur in great number and form a kind of cœnenchyma (" mesopores " Nicholson and Foord), and larger ones which are less numerous ("autopores" Nicholson and Foord). The smaller tubes, forming the cœnenchyma, are generally polygonal, provided with numberless tabulæ and the walls are often geniculated or so much deformed by the inflated tabulæ that the whole forms a mass of vesicles. In this vesicular cœnenchyma, only the uppermost layer, above the last set of tabulæ, was probably inhabited by living animals. These cœnenchymal tubes augment generally by fissiparity; only exceptionally an intermural gemmation seems to take place.

The larger tubes, the autopores, are the dwellings of the fully developed animals, the autozooids. They are mostly round or oval in their transverse section (generally not bilobed) and bear on one side a kind of callosity, which at its terminations projects slightly into the interior of the tubes, forming prominent edges which extend all along the tubes. These tubes augment by cœnenchymal gemmation.

The species belonging to this genus are generally incrusting.

According to this diagnosis one of the species occurring in the Salt-range must be considered as a *Fistulipora*. On the whole the difference between *Fistulipora* and *Dybowskiella* is very small. Both belong to the same type, and it is somewhat doubtful whether we shall meet with general approval in retaining the distinction even after Mr. Nicholson's recent paper. Yet we think the name *Dybowskiella* which we introduced already a year ago, trusting in Mr. Nicholson's former publications, may be retained, as the typical species of *Fistulipora* in transverse sections never appear as if the tubes of the polypites were composed of two separated and distinct parts which is generally the case in *Dybowskiella*.

The Salt-range form appears to be a new one, though it is more or less related to several of the species of *Fistulipora* described by Nicholson and Foord.

The species occurs in the middle division of the Productus-limestone and is therefore of a permian age.

1. FISTULIPORA PARASITICA, Waagen and Wentzel, n. sp., Pl. XLV, fig. 6; Pl. CV, figs. 1-4.

Corallum always forming thin incrusting lamellæ, never appearing in free lamellæ or branches. Surface provided with numerous monticules, but rarely with maculæ. Calices small, deep, apparently round. Their diameter is about 0·2mm. and there are about three of them within a length of 1mm. They are generally a little less than their own diameter distant from each other. The space between them is, when well preserved, occupied by a fine network, in the middle of which thin shelly crests run along, forming a network of larger meshes which encircle each of

the calices. These crests, if not well preserved, are transformed into fine granules, and then the spaces between the calices appear finely granulated.

In sections parallel to the surface the polypites show a pyriform outline, with two very small projections on the broader end. The cœnenchyma between them is well developed, being composed of numerous angular cells, the walls of many of which are thickened on one side in such a manner that many such thickened walls produce together calcareous lamellæ which surround the single polypites and form a polygonal network.

On account of the thinness of the colonies, it is extremely difficult to make transverse sections, in order to expose the polypites longitudinally. Our fig. 3*b*, Pl. CV, represents such a section; it is however very defective. One can only distinguish that the polypites have few straight complete tabulæ, and the septa-like projections are also partly distinguishable as thin dark lines. The cœnenchymal tubes are rather irregular, with geniculated walls and numerous tabulæ.

The materials at disposal were too scanty to make studies as to the gemmation of these fossils. From the transverse section represented in fig. 3*b*, however, it becomes highly probable that a cœnenchymal gemmation prevailed.

The size of the species was considerable, and chiefly the thickness of the lamellæ always remained very small, barely ever exceeding 1mm. The largest specimen known to us forms an incrustation on a specimen of *Spirifer musukheylensis*, Dav., and has been figured together with this latter specimen on Pl. XLV.

Locality and geological position.—There are altogether only three specimens of this species preserved in the Salt-range collection. All three were found in the middle division of the Productus-limestone; one forms an incrustation of a *Productus musakheylensis* from Chidru; the second envelopes the branching stem of a *Geinitzella* and comes from the highest beds of the middle Productus-limestone at Khura; the third incrusts a fragment of the shell of some Brachiopod and was collected by Mr. Wynne at Bilot.

Remarks.—This is one of those species which are to a certain extent transitional between *Fistulipora* and *Dybowskiella*. The shape of the polypites is that generally occurring in the former genus, whilst the existence of two pseudosepta, though they are rather rudimentary recall to a certain extent the latter. Yet the entire habitus of the form, its creeping mode of growth, and the not bilobed appearance of the polypites, are, as it seems to us, more in favour of its union with *Fistutipora* than with *Dybowskiella*, and thus we have decided on the former position for the species.

Among the species described by Nicholson and Foord in the genus there are several that are rather similar to the form here under consideration, but from all of them our *Fist. parasitica* is different by more distinctly developed pseudosepta and those prominent ridges that encircle the polypites.

Of other species hitherto described only *Fistulipora tuberosa*, Kays., shows a certain external similarity, as it also bears monticules; but the mode of growth of this form is entirely different, and the polypites seem to be devoid of any trace of pseudosepta, so that Kayser's species must be considered as a true *Callopora*.

Class: HYDROZOA.

Order: HYDROIDA.

Sub-Order: HYDROCORALLINA.

Family: *CŒNOSTROMIDÆ*, Waagen & Wentzel.

In taking up the study of the *Hydrozoa*, we encountered nearly insurmountable difficulties, as everything we took in hand would in no way agree with things already described; even after we had extended our studies to devonian specimens of true *Stromatoporidæ*, we were not much better off, as several of the characters which had till then been considered essential to the *Stromatoporidæ* could not be so recognised by us. In Zittel's Handbook, as well as in Nicholson and Murie's long paper on the subject, the *Stromatoporidæ* are described as composed of compact concentric lamellæ, supported on vertical pillars or rods, and leaving between them room for the sarcodic substance of the animal. Though it cannot be denied that in certain forms, such as *Ellipsactinia*, *Parkeria*, *Loftusia*, etc., such laminæ occur, yet in *Stromatopora* proper we failed to detect them. We must confess to having felt very uneasy on this account, and with great reluctance we accepted the fact which presented itself to us, and which could not be denied, though we made preparations over and over again and examined all our materials repeatedly.

We must then divide all the forms that are considered to be more or less nearly related to *Stromatopora* into two large groups; *viz.*, forms whose skeleton consists in reality of more or less compact concentric lamellæ, which are irregularly but not too frequently perforated, and are supported on vertical pillars; and, on the other hand, forms whose skeleton is composed of variously bent trabeculæ, disposed more or less distinctly in concentric layers, and leaving between them a system of reticulate or more or less vermiculate canals.

It is only the latter that we consider as belonging to the *Stromatoporidæ* in a wider sense, whilst the former compose a group that we consider with some hesitation as perhaps related to a certain extent to the *Hydractinidæ* and allied forms.

The observation that the skeleton of *Stromatopora* is not composed of compact lamellæ, but of successive sets of trabeculæ arranged more or less in one plane, so that in sections vertical to the surface of the hydrophyton a distinct lamination appears, which, however, does not exist in reality, but is only an apparent one, has been recorded already by Carter (hexactinellid structure), Bargatzky, and chiefly by Eugenia Solomko, who in her description of the "Stromatoporen des russischen Devons" says that the *Stromatoporæ* (which are taken by her to be *Pharetrones*) consist of horizontal, wavy, concentrically arranged rods which send out offshoots in a vertical direction and are thus united, leaving irregular spaces between them.

(Stromatopori Devonskoi Sistemi Rossii, page 11). This definition comes very near the truth, as we shall presently have occasion to demonstrate.

We start in the description of the different parts of the *Stromatoporidæ* from *Stromatopora concentrica*, of which species excellently preserved specimens are at our disposal. This species is on several accounts of great importance in this question; first, because it is the typical species of the genus (and not *Str. polymorpha* Gdf., as indicated by Nicholson); and, second, because in this species the so-called lamellæ deviate but very little from the horizontal plane, and can be brought easily within the plane of a section for tolerably large distances. In our considerations we have not laid so much stress on natural surfaces as on microscopical sections; as in the former the original condition seems to be in great part considerably affected by the process of fossilisation. As we had already occasion to state in the description of the *Monticuliporidæ*, the minute openings of the single cells are very frequently closed on the surface by an accumulation of sparry calcareous matter, which mostly presents a somewhat convex or hemispherical outline, and of which it is up to the present not certain whether it is of organic or inorganic nature, though the latter is more probable. Quite the same peculiarity we find again repeated in the *Stromatoporidæ*. The spaces between the single trabeculæ, which ought to appear as pores on the natural surfaces, are mostly closed by such a secondary deposit, and this is the same in calcareous and silicified specimens.

A peculiarity of the *Stromatoporidæ* that presents a great obstacle to the right interpretation of microscopical sections is the great difficulty experienced in the distinction between the matrix and the different parts of the skeleton, which difficulty originates in the circumstance that the matrix presents in most cases nearly absolutely the same pattern as the trabeculæ of the skeleton, and it depends solely on the mode of preservation, or on the level taken by a section, whether the one or the other is more conspicuous. Even the most acute observers (as for instance Quenstedt) seem to have fallen into errors in this respect, and to have described as skeleton in one section what has been taken to be the matrix in another (compare: Quenstedt, Petref. Deutschl., Vol. IV, part 1, pl. 141, figs. 10-11). There is one character by which the trabeculæ can be unmistakably recognised, which is, however, only rarely preserved, this is their minute structure. Already Baron Rosen has drawn attention to black points within the substance of the different parts of the skeleton of a *Stromatopora*, between which extend very fine dark lines, forming an extremely fine net-work of irregular meshes. Nicholson seems not to have observed these features, and also Bargatzky has only a very incomplete idea of them. As far as can be made out from his figures, he in some cases apparently mistook these dark structural parts, imbedded in the substance of the trabeculæ, for the trabeculæ themselves, and came so to very curious conclusions. Baron Rosen took these things to be the remnants of horny fibres, and therefore considers the *Stromatoporidæ* as horny sponges, whilst Zittel in his Handbook describes cracks within the substance of the skeleton in the section he examined as minute canals, and identifies them with Rosen's horny fibres. We have ourselves found these objects preserved in a

beautiful manner in a specimen of *Stromatopora concentrica* from the Eifel, of which we have figured horizontal and vertical sections, Pl. CXX, figs. 4 & 5. The real nature of them did not become quite clear to us. It does not seem that they are canals, as the matrix of the whole specimen is a white calcspar, and there is no reason why just these extremely fine canals should have been filled by a black matrix. It rather appears to us that these lines are parts of the substance of the skeleton, either of a darker colour, or different in density. It is now very remarkable that we have found absolutely the same structure to exist within the substance of the skeleton of a recent *Millepora*, preserved in the Zoological Museum of the University of Prague (Pl. XXI, fig. 4). But in this case also we are unable to state anything particular about the nature of these objects. They appear black and but little granular even with the strongest magnifying powers, and do not appear to be canals. Also in this case it seems to us most probable that they are composed of calcareous matter of a different colour. The remainder of the skeleton is of a finely granular texture. However this may be, even if these lines were produced by boring animals or plants, they are always an unmistakable sign of the parts bearing them being really trabeculæ, or parts of the skeleton (and not of the matrix).

With the aid of this character, we are now in a position to positively assert, in our sections of *Stromatopora concentrica*, what is matrix and what is skeleton. The section, Pl. CXX, fig. 4, extends parallel to the surface of the hydrophyton, and just cuts one of the so-called concentric lamellæ, so that the lamella itself falls within the plane of the section, and we see that the lamella is no real lamella, but that it is composed of variously curved meandering trabeculæ, leaving irregular spaces between them filled by matrix, which again exhibits about the same character as the trabeculæ but forming more isolated spots. If such a section is ground down a very little further, the whole aspect is changed. The spaces which formerly were occupied by the trabeculæ are now taken up by the matrix, and where formerly the matrix was observable the trabeculæ are now found. In other words, whilst within the horizontal layer of trabeculæ (generally taken to be a lamella) the trabeculæ are all continuous, and the matrix occupies separated masses ; in the spaces below and above this horizontal layer of trabeculæ the matrix is continuous, and the trabeculæ appear as isolated spots. The picture remains nearly the same, but the substances have changed. It is quite the same in sections vertical to the surface of the hydrophyton. We have figured such a section in Pl. CXX, fig. 5 ; we must, however, remark that the figure has not been placed in the right position by the artist. The horizontal layers of trabeculæ extend in the direction of the large black spots, placed vertically in the drawing. The section is again placed so that as many elements of the skeleton as possible fall within it. We see the horizontal layers of trabeculæ extend over the whole length of the section only rarely interrupted by ascending canals, filled by white matrix. The so-called interlaminar spaces appear as more or less isolated white spots of matrix. If again this section were ground down a very little, the whole aspect would be changed ; the white matrix would then form continuous masses ; *i.e.*, the "interlaminar spaces" would appear as continuous horizontal layers, con-

nected together by vertical canals, whilst the trabeculæ, of which the skeleton is composed, would appear as isolated gray spots within the white matrix.

From this it appears beyond doubt that the matrix can assume absolutely the same features as the skeleton, and that it is often almost impossible to distinguish between the two.

As the result of the whole consideration, it follows that the entire skeleton of the *Stromatoporids* is composed of irregularly bending trabeculæ, arranged at intervals in concentric layers, producing in vertical sections the appearance of a framework of square meshes. There is not a trace of compact concentric lamellæ. Now this composition of the skeleton of the *Stromatoporids* by numerous trabeculæ exactly agrees with what we have learnt from Moseley as existing in recent species of *Millepora*, which also consists of concentric layers, though not so distinct as in *Stromatopora*, and each layer is composed of numerous variously bending trabeculæ, leaving between them canals of the same description, occupied by the cœnosarc. The minute structure of these trabeculæ we have found in at least one species of recent *Millepora* to be the same as in the *Stromatoporids*.

What has been said up to the present applies chiefly to those forms of *Stromatoporids* which show a "rectilinear structure," as it has been termed by Carter. The forms that bear "curvilinear structure" are still far more easy to bring into accordance with *Millepora*. The trabeculæ extend in these forms in all directions, and so agree in every respect with what we see to occur in recent *Millepora*. Like the latter, the *Stromatoporids* with curvilinear structure also show an indistinct stratification within the skeleton. The forms with rectilinear and with curvilinear structure are, however, not fundamentally different, as both modes of structure can occur sometimes in one and the same specimen (see our Pl. CXVII, figs. 1 *c*, *d*).

The curvilinear structure can also take an extreme form, when the skeleton appears as a compact calcareous mass without any trace of stratification, and pierced by winding or vermicular canals in all directions (see our Pl. CXVIII, figs. 1 *a*, *d*). But even this mode of structure has its representative in a recent species of *Millepora*, the one figured by Moseley from Zamboangan (Phillipines), of which figure we have given a copy, Pl. CXXI, fig. 3 *c*.

Also *Sporadopora* has a similarly disposed skeleton. (A copy of Mr. Moseley's figure is given in Pl. CXXI, fig. 2.)

After having thus found that there is no fundamental difference in the trabecular structure between the skeleton of the *Stromatoporidæ* and that of the recent *Milleporæ*, we must now direct our attention more particularly to the canals which are occupied by the cœnosarc in recent forms. We can learn only the condition of the cœnosarc in fossil forms by the study of the matrix now occupying the space that was formerly taken up by it.

In the description of the trabecular part of the skeleton, we have seen that there remain between the several trabeculæ free spaces which in general shape exactly resemble the trabeculæ themselves, only that they are often somewhat more slender. These form canals which have served for the reception of the cœnosarc and compose

a system of regular or irregular meshes, as the case may be, being exactly similar to what has been figured by Moseley for *Millepora*. At the places where several branches meet, these canals show not rarely slight expansions of a round outline, which might be termed ampulla-like (compare Pl. CXVII, 1 *e, f*). Similar expansions, though perhaps not in the same degree, are to be found in the canal system of the *Stylasteridæ*, as figured plentifully by Moseley, and also to a certain extent in *Millepora*. This tortuous, either reticulate or vermiculate, canal system is common to all forms of *Stromatoporids*, as we have circumscribed the group above, and it shows clearly that all these forms must be more or less closely related to each other. Nevertheless there exist, on the other hand, differences more or less noteworthy between single forms, and these chiefly find expression in the canal-system; as in certain forms at the side of the reticulate or vermiculate minute canals there appear also larger ones which are absent in others. These larger canals, which exist in a great many forms, are of the utmost systematic importance, and require more particular consideration at our hands. The first who recognised the extreme importance of these canals was Carter, whose ingenuity in the definition and comparison of fossil remains with living forms has already often led to discoveries of the utmost interest, and who also in this case hit again on, or very near, the truth. Nobody before him had dreamed of associating the *Stromatoporids* with the *Hydrozoa;* and no sooner had Moseley published his admirable papers on *Millepora* and the *Stylasteridæ* than Carter recognised the near affinity that existed between these forms and the *Stromatoporids*, and gave up his old opinion that the latter were related to the *Hydractinidæ*.

These larger canals, which are to be found in most of the *Stromatoporids*, have very appropriately received from Carter the name of "*Astrorhiza*," and it is to these that we now wish to draw the attention of the reader.

The astrorhiza were first exactly described in a species from the devonian limestone of Dartington to which Carter gave the name of *Stromatopora dartingtonensis*.

The figure accompanying Carter's memoir is very instructive: it shows the astrorhiza to be composed of successive series of radiating branching canals, which unite in successive centres, of which one follows directly above the other, whereby an irregular vertically ascending tube is formed. The radiating canals are not horizontal but sloping, slightly ascending towards the centre of union. Similar canals had been already observed and described by Nicholson and Murie, but these authors state that only in some cases a median, vertically ascending canal is formed. Also Dawson mentions these canals, and affirms that in the centre of the radiating groups they are connected by vertical "tubes or groups of tubes, penetrating the whole mass." Afterwards, however, he falls into the error of bringing these vertically ascending canals into connection with his supposed hollow pillars—a supposition which is absolutely wrong, as in the whole skeleton of a *Stromatoporid* there is no part that is not solid. From all this it appears that vertically ascending canals are by no means of rare occurrence in the *Stromatoporids*, and that these are mostly

situated in the centre of astrorhiza. We were able to make the same observation in the materials from the Salt-range, where all the species possess such vertically ascending canals. The radiating canals are in some cases not so distinctly developed in the Salt-range species. Though Mr. Carter on the whole adheres to the opinion that the *Stromatoporids* are allied to the *Milleporæ*, yet he returns off and on to his old opinion of these fossils being *Hydractiniæ*, and thus compares the radiating canals of the astrorhiza to the grooved venation of *Hydractinia*. We think that such a comparison cannot take place, though Bargatzky also advocates it. The grooved venation in *Hydractinia* is occupied by the cœnosarcal stolon tubulation, from which, at the points of division, the different sorts of zooids arise. This stolonal tubulation forms part of the skeleton of *Hydractinia;* it is composed of tubes with compact walls, and the greater part of the cœnosarc is enclosed in these tubes. All this is different in the radial tubes of the *Stromatoporids*. They are tubes without walls, ramify indiscriminately, becoming at the same time thinner and thinner, and are very often at last entirely dissolved in the general tissue of the cœnosarc, which on its part forms winding canals around the different parts of the skeleton, as has been stated above. They form the means of inter-communication between the single zooids projecting from the hydrophyton, and either unite the radiating tubes of adjacent centres directly by their finer ramifications, or by means of the reticulated canals of the general cœnosarc.

If we restrict the term astrorhiza to the single type that has been described by Carter under the name, it would not embrace all the modifications which are presented by similar organs in the *Stromatoporids*. In the forms from the Salt-range there occur two other types, which are not of less importance. There is first a type represented by our new genus *Disjectopora*, having vertical canals connected at intervals by horizontal, not sloping, canals. These latter are not arranged in groups on the same level and thus forming star-like figures, but are placed singly at different levels, and having different directions. The second type, represented by our new genus *Irregulatopora* has, besides the cœnenchymal tubes, large winding canals, of which it is very difficult to decide what are vertical tubes and what lateral canals. Star-like figures are also not produced in this case.

Yet another case seems to occur, which has, however, not been observed by us in nature; it is that of star-like canals without the presence of a vertical canal uniting the successive centres. This seems to be the case in *Strom. astroites* Rosen, according to Bargatzky's indications.

Lastly, in some forms, like *Stromatopora concentrica*, every trace of large canals is absent, and the whole hydrophyton consists of nothing but cœnosarcal tissue.

If we wish to ascertain the nature of the organs represented by the different canals, we can best start from the genus *Disjectopora* mentioned above and represented on our Pl. CXVII, figs. 1*a*—*f*. The vertical section drawn in fig. 1*e* shows in the left hand corner one of the vertical tubes cut longitudinally. About in the middle of its extent we see a kind of tabula, and to the left of it one of the hori-

zontal canals that unite with the vertical tube. Higher up another of the horizontal canals is visible, but here already the vertical tube falls out of the plane of the section. If we now compare this section with the copy of Mr. Moseley's figure of *Millepora*, given on our Pl. CXIX, fig. 4, for comparison's sake, we find almost complete identity. The vertical tube corresponds to the tube of the mouthed zooid in Moseley's figure and the horizontal canals to the "main canals," as they have been called by Moseley; we think then it can no longer be doubted that in general the vertical tubes in the *Stromatoporids* correspond to the abodes of the zooids, and the star-like canals of the astrorhiza to the "main canals" of the *Milleporidæ*. The analogy between our genus *Disjectopora* and the other genera of *Stromatoporids* is very striking. If we take our new genus *Carterina*, figured in Pl. CXVIII, fig. 1, and Pl. CXX, fig. 3, we see on the first of those plates in fig. 1*b* and on the second in fig. 3, one of the astrorhiza as well developed as it can be seen in a section. They are in all respects identical with what we see in *Disjectopora*, with the sole exception that the lateral canals are horizontal in the latter genus and strongly sloping in *Carterina*. It is quite the same in all those *Stromatoporids* which bear astrorhiza, but which show at the same time a regular rectangular framework of trabeculæ, and which have received from Winchell the name of *Cœnostroma*. *Irregulatopora* is somewhat more removed from the general type, as in this form vertical tubes and lateral canals can barely be distinguished. Nevertheless this also belongs to the same type, and the whole number of forms we have mentioned up to the present belong to one compact group, which is as a whole more or less nearly related to *Millepora*, and must thus be considered as forming part of the *Hydrocorallina*.

In all these cases we have not yet spoken of the tabulæ, which are said to exist in the tubes of the zooids of *Millepora*, and which off and on are also observable in fossil forms. We have figured such tabula-like things in *Disjectopora* (Pl. CXVII, fig. 1 *e*) and in *Carterina* (Pl. CXX, fig. 3), but we regret to say that we were convinced that they are generally not tabulæ in the proper sense, but more or less like trabeculæ which cross the cavity of the tube and have fallen by chance within the plane of the section. Nevertheless it is probable that these trabecular structures have served for the same purpose as the tabulæ in the tabulate corals, that is, to shut off the lower part of the living animal from the dead parts of the skeleton. We are not quite certain whether or not in *Millepora* itself the so-called tabulæ are also of a trabecular nature, at least to a certain extent.

In recent species of *Millepora* the living part of the hydrophyton is extremely thin, not more than 0·5mm. If then the zooids at each stage of progress of growth of the hydrophyton were to deposit a tabula behind them, these ought to be extremely numerous. This is however not the case, neither in *Millepora* nor in the fossil forms, so it seems that only exceptionally are such formed.

If we thus consider the vertical tubes of the astrorhiza as the cavities into which the zooids retreated, we must bear in mind that only the uppermost parts of

these tubes just below the surface of the hydrophyton were occupied by the living animals, whilst all the remainder of the skeleton was dead.

This goes far towards the explanation of the remaining forms of *Stromatoporids*, in which vertical tubes do not exist.

There are two groups distinguishable among these forms, one with star-shaped canals (*Strom. astroites* Rosen) and one without these canals.

That these forms are most intimately connected with those previously treated of, nobody will deny. They possess absolutely the same trabecular skeleton, only the vertical canals are absent. Thus, it is extremely probable that animals of the same class have built up both sorts of skeleton—in this case animals very nearly related to *Millepora*,—and that the difference between the two classes of *Stromatoporids* consisted solely in the circumstance that in the one group with vertical tubes the single zooids could be retracted within these holes, whilst in the other group, without vertical tubes, the zooids could not be retracted within the skeleton, and were only imbedded in soft tissue at places where groups of cœnosarcal canals united (see Pl. CXXI, fig. 1*b*). From this consideration, however, the extreme systematic importance of the astrorhiza and corresponding organs is obvious. Every one who wishes to sub-divide the *Stromatoporids* into minor groups must start from this cardinal point.

According to what has been said up to the present, the *Stromatoporids* can be divided into two families: the *Cœnostromidæ* with vertical tubes, into which the zooids could retract, and the *Stromatoporidæ*, without such vertical canals, consisting only of a trabecular skeleton.

It is only natural that other observers, starting from other considerations, came to quite different results, and that their systematic arrangement of the different forms must be changed to a certain degree, to fit our sub-divisions. Since Baron Rosen's admirable paper on the structure of the *Stromatoporids*, several classifications have been published, as by Nicholson and Murie, by Bargatzky and by Eugenia Solomko. The first have considered the *Stromatoporids* as calcareous sponges, the second as *Hydractinæ*, and the last as *Pharetrones*.

The first and the last of these opinions are not fundamentally different, as the *Pharetrones* are generally also considered as calcareous sponges of a certain sort. Howsoever this may be, Nicholson and Murie were not very confident in their identification of the *Stromatoporids* with calcareous sponges. They say, p. 231 of their paper in the Linnean Society: "In all the known *Calcispongiæ* the skeleton consists of free spicules, which are never amalgamated or fused with one another, and which, therefore, never form a continuous frame-work, however densely they may be packed together. In no *Stromatoporid*, however, have free calcareous spicules ever been detected by any observer, and the skeleton is undoubtedly a more or less continuous one. If then we were to accept the view that the *Stromatoporidæ* were really referable to the calcareous sponges, we should have to assume that they constitute a special, peculiar group bearing a relation to the typical *Calcispon-*

giæ somewhat similar to that which the *Lithistidæ* or *Hexactinellidæ* of the present day bear to those silicious sponges in which the spicules are not united or soldered together (*Sarcohexactinellida* of Carter, *Lyssakina* of Zittel)." The opinion expressed in these sentences is perfectly sound, so long as the skeleton of the *Stromatoporids* cannot be brought into accordance with any other group of animals without another assumption, but as soon as an affinity can be directly established, Messrs. Nicholson and Murie's assumption must fall, and the similarity between the *Calcispongiæ* and the *Stromatoporids* can only be considered as an apparent one, and not as existing in reality. Now, we have endeavoured to show on the foregoing pages that there exists a real affinity between the *Stromatoporids* and the *Milleporæ*. This affinity is not only supported by similarities in the structure of the skeleton, but also by the discovery of transitional forms between the two groups in the Productus-limestone of the Salt-range.

Under the same head falls also Miss Eugenia Solomko's opinion, that the *Stromatoporids* were *Pharetrones*. She also was not in a position to give proof of the existence of calcareous spiculæ in the *Stromatoporidæ*, a character which is essential according to Zittel and Dunikowsky.

More difficult is it to disprove the opinion formerly held by Mr. Carter, and lately accepted by Bargatzky, that the *Stromatoporids* were *Hydractiniæ*, though the difference between the two is in reality very great. The hydrophyton of the *Hydractiniæ* commences with a fine tissue of chitinous tubes, in which the cœnosarc is enclosed. These tubes, or stolons, which can in some cases also be calcareous, are separated from each other by wide spaces; in the *Stromatoporids*, on the contrary, the canals containing the cœnosarc are kept separate by solid calcareous trabeculæ, forming a continuous skeleton just as in the *Milleporids* and *Stylasterids*. Allman's indication that the outer side of the chitinous skeleton of *Hydractinia* was covered by soft naked ectoderm has been refuted by Grobben (Sitzgsber. Wien. Acad. d. W. 1875) in much detail, and he has proved that in the stolonal parts, as well as in the large and small spines, the ectoderm is contained within the chitinous covering; even the interlaminar spaces are probably without cœnosarc. The large and small spines are considered by Grobben as the dwellings of singularly metamorphosed zooids, which have received from him the name of skeleton zooids. All this does not obtain in the *Stromatoporidæ*. If Bargatzky compares the polygonal reticulation, which appears sometimes within the trabeculæ of the *Stromatoporids*, and which we have figured, Pl. CXX, fig. 5 *b*, as equivalent to the polygonal meshes produced by the stolonal tubes of the hydrophyton of *Hydractinia* the error is obvious. In *Stromatopora* this dark reticulation is probably occasioned by differences in structure or colour of the calcareous masses composing the skeleton, perhaps made visible only by secondary processes, and the spaces between the dark parts are filled with the calcareous substance of the skeleton, whilst in *Hydractinia* the stolons are separated from each other by empty spaces, or a fine film of chitinous substance. From all this it appears that the difference of the *Stromatoporids*

and the *Hydractiniæ* is very considerable, whilst on the other hand the similarity to the *Milleporids* is striking.

If then the general opinion held by the above-mentioned authors cannot be retained, the sub-divisions of the whole group founded on such erroneous suppositions can only be accepted with great caution; and thus also the genera introduced by Nicholson and Murie, as well as by Bargatzky, can apparently be only partly retained. By Nicholson and Murie the greatest stress is laid on the condition of the reticulated part of the skeleton, whether it is composed of distinct layers or not, &c. We have seen above that the lamination is of minor importance, and that even in one and the same specimen the trabeculæ can be partly arranged in distinct concentric layers, partly not; and thus we cannot accept the distinction as drawn between *Stromotopora* and *Clathrodictyon*. The genus *Pachystroma* we had ourselves occasion to examine closely, as, if we are not much mistaken, the specimen of *Stromatopora concentrica* we have figured in Pl. CXXI, fig. 1, must be considered as belonging to this genus. We have found that the singular structure of *Pachystroma* is simply produced by a peculiar preservation of certain specimens of different species of *Stromatopora*, inasmuch as in such specimens certain zones of the skeleton are either entirely or partly converted into a ferruginous matter, whilst the remainder consists of grey limestone. The transformation has been most complete along the margins of the specimens, and less so in the interior. Thus, in the vicinity of the margins, the small zones separating the calcareous layers from each other consist exclusively of ferruginous matter, which very easily decomposes by weathering; and in consequence of this the lateral surface of such specimens acquires a plaited appearance, as has been figured by us, Pl. CXXI, fig. 1 *a*, or by Nicholson and Murie in the Journal of the Linnæan Society, 1879, Pl. 4, fig. 2. In sections, in these marginal parts of the specimens, these ferruginous zones appear either entirely empty or only occupied by a compact ferruginous layer, so that the thick calcareous parts appear as if not united by vertical pillars. More towards the interior of the hydrophyton, however, the ferruginous layers become less continuous, they are often traversed by calcareous trabeculæ, and one easily recognises that originally the ferruginous layers were of the same structure as the remainder of the skeleton, and that they only have been brought into existence by a secondary transformation of the mineral substance by which the whole hydrophyton was fossilised. Now, it is not absolutely necessary that such transformation should result in a ferruginous substance; other changes may supervene; but in every case, by such chemical processes, the appearance is brought about as if the specimen were composed of thick rather compact calcareous layers, separated from each other by thin laminæ, in which nothing, or very few elements, of the skeleton can be observed, thus giving to the whole the appearance that has been described under the name of *Pachystroma* by Nicholson and Murie. This is distinctly demonstrated by our figures Pl. CXXI, fig. 1 *c*, and Pl. CXX, fig. 5 *a*. Thus, it appears that *Pachystroma* is not a genus of independent value, but must be merged partly into *Cœnostroma* partly into *Stromatopora*.

Another genus created by Nicholson and Murie is *Stylodictyon*. According to the figures given in the Linnæan Society's Journal, it seems that very different things have been subsumed under the name. The species that has been quoted as type species is rather imperfectly known, as the figures given are drawn on too small a scale to allow of a distinct reproduction of the characters. We think that, so far as can be made out from these drawings, the figures 4 and 5 of *Stylodictyon columnare* represent something of which we cannot judge, but which looks very much like *Labechia*, whilst the other figures, chiefly those of *Stylodictyon retiforme* (fig. 1—3, Pl. 3, Journ. Linn. Soc. Zool., Vol. XIV, 1879) point to quite different affinities. In this species appear real concentric plates supported on vertical pillars as in *Ellipsactinia* or *Circopora*, which we shall have to describe later on in the text, and thus this *Styl. retiforme* belongs to that group of forms which we have separated above entirely from the *Stromatoporids* and which we have designated as perhaps somewhat related to the *Hydractiniæ*.

Of the remaining two genera of *Stromatoporids* emended or described by Nicholson and Murie, *Stromatocerium* Hall, and *Dictyostroma* Nicholson, we cannot judge, as figures and descriptions are not sufficiently explicit. We shall, however, recur to the latter genus in discussing Solomko's classification of the *Stromatoporids*.

Only *Cannopora*, Phillips, with its allies, *Diapora*, Bargatzky, and *Parallelopora*, Bargatzky, require yet some notice. F. Roemer has already, some time ago, expressed the opinion that *Cannopora* was nothing but a *Syringopora* encrusted by a *Stromatopora*, and Bargatzky's figure of *Cannopora placenta* does not quite remove such a suspicion. We had ourselves no occasion to investigate the minute structure either of *Cannopora* or of *Diapora*, and therefore we cannot pass a definite judgment on these things; but if one considers the observations published by Baron Rosen on the incrustation of foreign bodies, and on the power of dissolving these bodies by the animals of the *Stromatoporæ*, also that the recent *Milleporæ* and *Hydractiniæ* are encrusting animals that dissolve the calcareous bodies on which they grow, Prof. Ferd. Roemer's opinion gains much in probability. This applies as well to *Diapora* as to *Cannopora*, the difference between the two genera being in fact very small. As regards *Parallelopora*, Bargatzky, we must confess that we cannot find any difference between Bargatzky's figures and a *Heliolites*.

The genus *Stachyodes*, published somewhat later by Bargatzky, might be a *Stromatoporid*, but the figures are so bad that it is impossible to decide the question. If *Stachyodes* represents a *Stromatoporid*, it then might perhaps be somewhat related to our *Irregulatopora*.

There remains yet to say a few words on *Labechia*. This genus has been long since recognised by Lindstroem as not belonging to the corals, with which it had been united by Edwards and Haime. But Lindstroem believed these things to be *Hydractiniæ*, an opinion which has been refuted by Nicholson on good grounds. A question that appears to us not yet settled beyond doubt with regard to *Labechia* is, what, in the thin section figured by Nicholson, is to be regarded as parts of the

skeleton, and what as the matrix. If we should judge from the appearances generally presented by thin sections of *Stromatoporids*, we should regard the dark parts as matrix and the light-coloured parts as skeleton, as such distribution of the different colours can very often be observed. The explanation of *Labechia* would then be very simple. The "calcareous columns" were the tubes, in which the zooids were located, and which intercommunicate freely by thin curved canals. The skeleton would consist of thick curved trabeculæ, separated from each other by the canals. That the so-called "calcareous columns" project as blunt spines above the general surface presents no difficulty to such an explanation if one considers the widely spread peculiarity which is of general occurrence in the *Monticuliporidæ*, the *Bryozoa*, etc., that such thin tubes get closed by a secondary deposit of calcspar which mostly protrudes from the tubes as a blunt hemispherical mass. We had not sufficient materials of *Labechia* at our disposal to make sure of this conjecture, but we wish to draw the attention of further observers to this point.

The first attempt at a thorough classification of the *Stromatoporids* was made by Miss Eugenia Solomko (St. Petersburg, 1886), and though she has given no names to the several groups distinguished by her, yet this attempt must be considered as of some importance. As the paper appeared in the Russian language, it will perhaps be gratefully accepted if we give a short sketch of her system before entering into details with regard to it.

She considers the skeleton of the *Stromatoporids* as built up of concentric layers, which are composed of horizontal and vertical rods, and in the most complete development each such layer possesses above and below such a series of horizontal rods, which are united by vertical rods or pillars.

This fundamental type is, however, only rarely to be observed; generally it is more or less stongly modified, and it most frequently occurs that one of the systems of horizontal rods is absent. According to these peculiarities Miss Solomko distinguishes two types:—

TYPE I.

Species with a true stratification of the skeleton, which is brought about by interspaces between the several layers.

1. Group: *DILAMELLATA.*

The layers consist of a series of horizontal rods above and below, connected by vertical pillars; the layers are separated from each other by empty spaces.

2. Group: *MONOLAMELLATA.*

The layers are very dense in consequence of the small development or entire absence of the vertical pillars, whereby the upper and lower systems of horizontal rods unite, forming one compact lamella. The canal system is formed:—

(*a*) either by off-shoots sent out by each layer (*Clathrodictyon*, Nicholson and Murie), or

(*b*) by absence of any communication between the single layers, which in their turn are pierced by vertical canals (*Stromatocerium*, Hall, *Pachystroma*, Nicholson and Murie).

TYPE II.

Species with false stratification of the skeleton, formed by interspaces between the vertical rods or pillars. The skeleton consists in reality only of horizontal rods, which bear thickenings at intervals appearing as vertical pillars.

1. Group: (*DICTYOSTROMA*, Nicholson).

The pillars are not united with the horizontal rods above them. According to the distribution of the pillars, several sub-groups can be distinguished :—

(*a*) The pillars are irregularly distributed; thickness of the horizontal rods varies: *Stromatapora dentata.*

(*b*) The pillars are arranged regularly in superposed rows, such forming vertical columns (*Strom. ungerni*, Rosen).

(*c*) The pillars are grouped at certain places, forming double rows (*Stromat. geometrica*, Solomko).

2. GROUP.

The pillars are entirely united with the horizontal rows above :—

(*a*) There are groups of horizontal canals forming star-like figures,

(*b*) Such canals are absent (*Strom. concentrica*, Gdf).

This is the essence of Miss Solomko's classification.

What we most strongly object to in this essay is that the author does not adhere strictly to her own definition of the skeleton of the *Stromatoporids*, as composed of horizontal and vertical rods. We see in her classification suddenly appear the expressions "*Dilamellata* and *Monolamellata*," indicating a return to the old opinion that the skeleton of Stromatoporids was built up of concentric lamellæ. If we stick firmly to the definition that the skeleton consists of a mesh-work of trabeculæ, the true stratification as defined by Solomko becomes a very problematic affair. The inter-spaces between the several layers are then nothing but longitudinal canals within the substance of the horizontal trabeculæ. Even if such canals existed, this would not be of very much importance, as they are decidedly absent in the majority of cases; and when they are present, they must somewhere communicate with the remainder of the cavities containing the cœnosarc. We must, however, confess that Solomko's figure of *Cannopora perforata* does not remove the strong doubts that we have already expressed with regard to the empty interspaces that are said by her to constitute the true stratification of the skeleton. These spaces look in her figure very much like cracks or fractures, and in this respect extremely like the cracks represented in Zittel's woodcut; only that in this case also the vertical pillars have been traversed by them. According to our experience such cracks are very easily produced in grinding down the specimens. But there is yet another cause, which often gives the appearance as if canals were

present; this is the peculiarity of preservation which we have observed in a great number of microscopical sections in the *Monticuliporidæ*, as well as in the *Stromatoporidæ*, and which consists in the circumstance that the central parts of the several calcareous elements, of which a skeleton is composed, very often present a different colour from the peripheral parts of the same elements. This has already led Mr. Nicholson to consider his so-called spiniform corallites as open tubes, which they never were, and it may have led Miss Solomko to see canals, where there never were any. At least Mr. Nicholson has not observed these canals in his investigation of *Cannopora perforata*.

If considerable doubts are thus raised as to the real existence of the first group, the *Dilamellata*, this is in a far higher degree the case with the *Monolamellata*. In these Miss Solomko considers the layers of which the skeleton is composed as compact, inasmuch as the upper and lower series of horizontal rods of each layer have been united, and the vertical rods have entirely disappeared. The mesh work, which is nevertheless exhibited by many of these forms, she explains by inflexions of the layers, so that at last one layer is united to the other, as is to be observed, according to her views in *Clathrodictyon*. In other cases these inflexions are entirely absent, and one compact layer follows above the other, without being united, as in *Pachystroma*. Of this latter genus we have shown above that it has probably no real existence, that it is nothing but a modification caused by a singular mode of preservation of *Stromatopora*. Thus, this case of the *Monolamellata* is certainly invalid. But the other case also is highly doubtful, as there exists not the slightest proof that the horizontal trabeculæ in *Clathrodictyon* must be considered as morphologically different from the trabeculæ in *Stromatopora concentrica*, which forms part of Solomko's second type. This distinction then, which is thus introduced into the matter at discretion, is wholly artificial, and not founded in nature.

Thus we see that the so-called "true stratification" of Miss Solomko does not exist in reality, or at least cannot be distinguished from the "false stratification" as it occurs in *Stromatopora concentrica*, and we come to the conclusion that there exists in reality only one mode of stratification in the *Stromatoporids*, which is brought about by the reticulated canals which once contained the cœnosarc.

One point of Solomko's classification is, however, of importance: this is the distinction of the group containing *Dictyostroma*. The forms brought together in the different groups united under the above heading are chiefly *Strom. ungerni* Rosen, *Strom. dentata* Ros., *Strom. geometrica* Solomko, and *Strom. inostranzewi* Solomko.

The first two of these species have been commented on already by Carter, who thinks them to bear an evident similarity to *Hydractinia*, and it cannot be denied that the spines which are in great number distributed on the surface of these species, as well as apparently in large cavities, look very similar to like organs of *Hydractinia* and *Podocoryne*. It must, however, be remarked that in these recent genera the spines are mostly hollow and filled with cœnosarc, and have been considered by Grobben to contain a particular sort of zooid, the skeleton zooids. In

the fossil forms, on the contrary, as is evident from Solomko's figures, these spines are solid, and thus the similarity to the spines of *Hydractinia* is only an apparent one.

That all these forms can be comprised in one natural group, which may best receive the name of *Dictyostroma*, Nicholson, is evident. Also their general difference from *Stromatopora* cannot be much doubted, but to say more on the matter is not possible at present. We have had no specimens of this group at our disposal, and can therefore not judge of it; for the moment we place it somewhere in the vicinity of *Stromatopora*.

We have thus seen that the classifications of the group hitherto proposed cannot be applied without precautions. Nicholson and Murie have proposed to form a proper family, the *Stromatoporidæ*, which, on the whole, can be retained though it has been considered by those authors as forming part of the *Calcispongiæ;* but there must be removed from it those forms that are more nearly related to *Millepora* than *Stromatopora* itself. We have demonstrated in the course of our investigations that the forms subsumed by Nicholson and Murie in the family *Stromatoporidæ* must be divided into three parts: first, the genus *Stylodictyon* Nicholson and Murie, which does not comprise any form belonging to the *Hydrocorallina*, and which thus must be altogether eliminated; second, forms in which vertical tubes for the retraction of the zooids do not exist, but in which the whole skeleton is only composed of a more or less reticulated mass of trabeculæ, sometimes traversed by horizontal canals; and, third, forms in which the whole skeleton is traversed by vertical or winding tubes destined for the reception of the animals.

The non-existence of such tubes in certain forms is of the utmost morphological importance; and it appears impossible to leave in one and the same family forms with and without such tubes. We thus cannot but consider the two groups, above indicated as forming two different families.

Thus we arrive at the following classification of the *Hydrocorallina*:—

I. Family: STYLASTERIDÆ, Grey.

Hydrophyton consisting of a cœnosarc composed of reticulated canals, which are separated from each other by a trabecular skeleton, in which large tubes are imbedded for the reception of the zooids. The tubes of the mouthed zooids are nearly always provided with a median columella and mostly show a series of pseudosepta all round. The pseudosepta are generally united by their internal margins, and thus form interseptal loculi. The external appearance of the skeleton is very variable, depending chiefly on the more or less strong development of the trabecular parts of the skeleton in different forms.

Of the genera belonging to this family, only *Stylaster* has been found in a fossil state up to the present.

The genus *Sporadopora*, Moseley, forms to a certain extent a connecting link between the *Stylasteridæ* and the *Milleporidæ*. From the Salt-range we shall have

to describe the genus *Carterina*, which can be considered more or less as a connecting link between the *Stylasteridæ* and the *Cœnostromidæ*.

II. Family: MILLEPORIDÆ, Moseley.

Hydrophyton composed of an irregular mesh-work of fine canals separated from each other by a trabecular skeleton. Within this trabecular mass, vertical tubes of two sizes are distributed into which the differently shaped zooids can be retracted. The tubes are generally arranged in groups, one larger, surrounded by a number of smaller ones. From these tubes larger canals are sent off in a horizontal direction. Within the tubes a columella and pseudosepta are absent, but they are mostly provided with tabulæ.

The general appearance of the entire hydrosoma is either encrusting or forming flattened branches, mostly with slight elevations or tubercles on which the openings of the tubes for the reception of the mouthed zooids are placed.

Besides the genus *Millepora*, which occurs also in a fossil state in tertiary strata, there are quoted in Zittel's Handbook three other genera as belonging to the family: *Axopora*, E. and H., *Porosphæra*, Steinm., and *Cylindrohyphasma*, Steinm. Of these the first might perhaps belong to the family, the second must certainly be excluded, and the third is a quite problematic thing, the description of which is too short to allow of any conclusion. As far as the macrostructure of the fossil can be judged from the figures, it does not appear quite improbable that it should belong to the *Milleporids*, but the microscopical section figured by Steinmann is so singular, not showing any of the larger tubes in connection with the general tissue of the skeleton, that all comparison with *Millepora* ceases.

III. Family: CŒNOSTROMIDÆ, Waagen and Wentzel.

The calcareous skeleton of the hydrophyton forms polymorphous masses of generally more or less tuberous outline. Surface of the hydrophyton wavy or covered with little tubercles, and strewn with small apertures, which are mostly distributed irregularly and only sometimes united into little groups. They form the entrances to vertical tubes, into which the zooids were able to retract. These vertical tubes inter-communicate either directly by mostly sloping or horizontal canals, the branches of the astrorhiza, or this communication is not direct, inasmuch as between the astrorhiza of adjacent centres a mesh-work of fine canals is intercalated. Sometimes the communication between the vertical tubes is entirely taken up by these small winding or reticulated canals, which traverse the entire trabecular skeleton. The vertical tubes, and even exceptionally the lateral canals show sometimes trabecular tabulæ. The whole mass of the skeleton is made up of solid, anastomosing, calcareous trabeculæ, which are either arranged in parallel zones, so that in vertical sections a rectangular mesh-work appears, or the trabeculæ extend irregularly in all directions, whereby the mesh-work becomes also irregular.

The trabeculæ contain black-coloured, polygonal, intersecting calcareous fibres, which are mostly thickened at the points of intersection, or they possess a simply

granular structure. The cœnosarc forms in general a net-work of fine canals, which at the points of intersection show mostly ampulla-like dilatations.

On the whole, this family is very nearly related to the preceding one, and for long we were much in doubt whether it was altogether possible to distinguish it from the *Milleporidæ*. The reasons which led us at last to the distinction are the following:—

1. The absence of a distinct grouping of the tubes of the zooids.
2. The absence of a difference in size between the tubes of the mouthed and those of the mouthless zooids.
3. The arrangement of the trabeculæ in a regular quadrangular framework.
4. The very characteristic fashion in which the radiating canals are distributed round the vertical tubes of zooids.

All these points together seemed sufficient to distinguish the group of the *Cœnostromidæ*, as a proper family, from the *Milleporidæ*.

Which of the genera hitherto described may belong to the family is rather difficult to indicate, as just the most important characters have been generally neglected in the distinction of genera up to the present. The most typical form of the family is, as far as we can make out, apparently represented by the genus *Cœnostroma* Winchell. It is however very much to be regretted that the papers in which Winchell has established the genus are apparently very rare, so we also were as little in a position to examine their contents personally as Nicholson and Murie had been. As, however, it is known that the genus has been founded on the presence of astrorhiza, that is of star-shaped canals on the surface, and that, if such occur, they generally are connected by a central tube, we consider the genus *Cœnostroma* to comprise such of the *Stromatoporids* as possess vertical tubes into which the zooids were able to retract, surrounded by sloping radial canals. These characters are most strikingly developed in *Stromatopora dartingtonensis* Carter, and therefore we should like to introduce this one as the typical species.

The genus *Cœnostroma* has generally been considered identical with *Stromatopora*, and it apparently is so, if one takes *Stromatopora polymorpha* Gdf., to be the type. Against this, however, there can be adduced that *Strom. polymorpha* is a true *mixtum compositum* of different forms (Bargatzky has shown that there were not less than five different species comprised under the name), and that in reality it is *Strom. concentrica* Gdf., which must be considered typical of the genus *Stromatopora*. Not only that *Strom. concentrica* is figured on an earlier plate (VIII) of Goldfuss's works than *Strom. polymorpha* (which is figured on Pl. LXIV), but also the first figure, fig. 8 *a*, of the latter, which ought to retain the name "polymorpha" if the other figures are recognised to represent other species, is identical with *Strom. concentrica*, so that there is no escape but to take *Strom. concentrica* as the typical species of the genus *Stromatopora*. Now, it is well known that this latter species possesses no astrorhiza, and thus it is evident that the name *Stromatopora* must be applied to forms without such. So we must distinguish generically between *Cœnostroma* and *Stromatopora*.

We thus have as the first genus of the family to quote—

1. Cœnostroma, Winchell, 1866: Proceedings, American Association;—Nicholson and Murie: Jour. Linn. Society, Zoology, Vol. XIV, 1879, pp. 191, 217.—Hydrophyton polymorphous; the skeleton composed of trabeculæ forming mostly a rectangular mesh-work, and being arranged more or less distinctly in concentric layers. Surface generally provided with tubercles, on which mostly the centres of the astrorhiza are situated. In these centres vertical tubes open, into which the zooids were able to retract. Typical species, *Cœnostroma dartingtonense* Carter, sp.

The genus seems to be restricted to upper-silurian and devonian strata.

It is doubtful whether those species which show several vertical tubes grouped together, like *Strom. polyostiolata* Bargatzky, or *Strom. typica* Rosen, ought not to be considered as generally different.

2. Carterina, Waagen and Wentzel, n. gen.—Hydrophyton reversed conical; skeleton composed of trabeculæ, forming a quite irregular mesh-work, showing no stratification whatever. Tubes for the retraction of the zooids numerous, irregularly bending, provided with trabecular pseudosepta, and thus in transverse section mostly star-shaped; lateral canals very strongly sloping, about of the same width and the same description as the principal tubes, arranged radially round the latter; trabecular tabulæ, of very rare occurrence.

Typical species: *Carterina pyramidata* Waagen and Wentzel, n. sp. The genus has been found up to the present exclusively in the Productus-limestone of the Salt-range.

By the existence of pseudosepta though in a trabecular form, the present genus recalls to a certain extent the characters of the family *Stylasteridæ*.

3. Disjectopora, Waagen and Wentzel, n. gen.—Hydrophyton reversed conical; skeleton composed of trabeculæ which form a tolerably regular, rectangular mesh-work and are arranged in concentric layers. Tubes for the retraction of the zooids rather far distant from each other, tolerably straight, sometimes provided with tabulæ; lateral canals generally narrower than the main tubes, horizontal not sloping, radiating singly at different levels.

Typical species: *Disjectopora milleporæformis* Waagen and Wentzel, n. sp.

The genus is restricted to the Productus-limestone of the Salt-range.

In general arrangement of the several parts the present genus comes very near *Millepora*.

4. Irregulatopora, Waagen and Wentzel, n. gen.—Hydrophyton lamellar or flatly conical; skeleton composed of irregularly arranged trabeculæ, forming an irregular mesh-work; no stratification; tubes for the retraction of the zooids very irregularly bending and barely distinguishable from the lateral canals, which probably also exist. Trabecular tabulæ sometimes present.

Typical species: *Irregulatopora undulata* Waagen and Wentzel, n. sp.

The genus has been found up to the present only in the Productus-limestone of the Salt-range.

These are the forms we can assign for the present with certainty to the family. We regret to say that we are unable to introduce any of the generic names applied by Nicholson and Murie. We have already stated our reasons in this respect. The only genus which is certainly a distinct one, *Dictyostroma*, belongs to the next family. On *Cannopora*, *Diapora*, and *Stachyodes* we cannot judge, having not studied them in nature. If their structure is a feature belonging originally to them, then they must be placed in the present family.

IV. Family: *STROMATOPORIDÆ.*

The calcareous skeleton of the hydrophyton forms polymorphous masses of a partly laminar, partly tuberous outline. It consists of solid trabeculæ, which are mostly arranged in regular concentric layers, and form thus a framework of rectangular meshes; sometimes, however, they are also arranged irregularly. The trabeculæ are sometimes swollen at the points of intersection, and sometimes their horizontal branches send out processes which do not reach the next following horizontal layer. Between the trabeculæ extend canals of the same appearance as the trabeculæ, which either form also a rectangular network, and then at the points of intersection they are often widened, or they are vermiculate and very irregular. Larger radiating canals, which are not in connection with vertical tubes, are present in some forms. The zooids were either placed at the centres of these radiating canals, or, where these are absent, at places where a greater number of the canals of the cœnosarc come together (Pl. CXXI, fig. 1 *b*). These are then also arranged in a more or less radiating manner. There were no openings for the retraction of the zooids within the skeleton.

The intimate structure of the trabeculæ is as in *Cœnostroma:* they contain fibres of a dark calcareous mass, forming a network and being swollen at the points of intersection, or the whole mass of the trabeculæ is simply finely granular.

The genera belonging to this family are not numerous, though it is probable that they can be augmented considerably. At present we can distinguish the following genera:—

1. Stromatopora, Goldf., 1826: Petref. Germ. I., p. 13, Pl. VIII, f. 5.—The hydrophyton attaining considerable dimensions, mostly tuberous in shape; trabeculæ forming a more or less regular network, where a distinct stratification of the skeleton is attained; radial canals are absent.

Typical species: *Strom. concentrica* Goldf.

The genus seems of an exclusively devonian distribution.

2. Rosenia, Waagen and Wentzel, n. gen.—We introduce this name for those forms which are, like *Stromatopora*, devoid of vertical tubes, but which at the same time possess radiating canals. The skeleton is generally composed of a regular network of trabeculæ.

Typical species: *Rosenia astroites* Rosen, sp. (Bargatzky: Verh. d. naturhist. Vereins d. Preuss. Rheinl. u. Westph., 1881, p. 284).

The genus seems to occur in silurian and devonian strata.

3. Porosphæra, Steinmann, 1878: Palæontographica, Vol. XXV, p. 120, Pl. XIII, fig. 812.—Hydrophyton sphæroidal, never very large. Trabeculæ of the skeleton forming a very irregular network, a stratification of the skeleton is not observable. Sometimes, but not always, there appear radiating canals.

Typical species: *Porosphæra globularis* Phill., sp.

The genus is restricted to cretaceous beds.

It is somewhat doubtful whether this genus is rightly placed here, but for the moment the present position seems the most probable one.

4. Dictyostroma, Nicholson, 1875: Palæont. of Ohio, Vol. II, p. 254.—This genus represents a rather far deviating type, in which the trabecular parts of the skeleton have experienced a strange modification. There is chiefly the horizontal part of the trabeculæ developed, whilst the vertical extensions are transformed into thick protuberances, which only partly unite with the following horizontal layer. Vertical tubes for the reception of the zooids are absent.

Typical species: *Dictyostroma undulatum* Nich. (other species: *Dictyostr. ungerni* Rosen, *dentatum* Rosen, etc.).

The chief distribution of the genus seems to be in upper silurian strata.

With this genus the number of generic types we can at present assign to the family is at an end.

Of all these genera and families only one family, the *Cœnostromidæ*, is represented in the Salt-range. Three of the genera we were able to quote in this family have up to the present been exclusively found in the Salt-range, and they are of special interest as transitional forms between the old *Cœnostromids* and the recent *Milleporids*. It was mainly this intermediate position that led us to a right understanding of the *Stromatoporids* at large, and we could not abstain from exposing the results of our studies on the other forms in this place, as they bore also on the position of the Salt-range forms. This intermediate position, however, is also in accordance with the geological position of the beds in which these things occur, and constitutes a highly interesting instance of the degree of accuracy with which one can judge on the age of a bed by the analogy of its organic contents with geologically older and more recent forms of life.

Genus: CARTERINA, Waagen & Wentzel, n. gen.

We can be brief in the description of the genera, as well as of the species, as the most important points of the organisation of these forms have been already mentioned above.

In this genus the hydrophyton is massive and of considerable dimensions. It is composed of trabeculæ which form a very irregular network, leaving winding, more or less vermicular, canals between them, in which the cœnosarc was contained. A regular, more or less rectangular network, as is observable in many of the other genera of *Cœnostromids*, does not occur in this genus. The canals sometimes show

irregular widenings, a sort of lacunæ, as also sometimes exist within the skeleton of *Sporadopora*, a genus of the *Stylasterids*.

This trabecular skeleton is traversed in all directions by larger tubes, which show a characteristic arrangement. There is, as in *Cœnostroma dartingtonense*, a central tube, which we consider as the dwelling-place of the mouthed zooids. This central tube is surrounded by a number of sloping radial canals of nearly the same width as the central tube, which in an irregular way approach more and more the latter, and at last unite with it from opposite directions at the same time. This takes place repeatedly at different levels.

The central tubes, as well as the radiating canals, are often traversed by trabeculæ, which are either single or gathered in groups, and which perhaps have had the functions of tabulæ.

The central tubes, and perhaps also the radiating canals, are provided with a small number of trabecular pseudosepta, which give to the transverse section of these tubes, in the plane of the pseudosepta, a singular star-shaped appearance.

The present genus is very nearly related to *Cœnostroma* Winchell. It has the same distribution of the calices, or central tubes, with regard to the radiating canals, but the trabecular skeleton is more irregular, the canals of the cœnosarc often form small lacunæ as in *Sporadopora*, and the calices possess distinct trabecular pseudosepta, all characters which do not occur in *Cœnostroma* and which make absolutely necessary a generic distinction between these and the Indian fossils.

It has been remarked already above that the present genus possesses certain characters which approach it more or less to the *Stylasteridæ*. These characters are the existence of pseudosepta and the extreme irregularity of the trabecular skeleton, which on the whole more resembles that of *Sporadopora* than that of *Millepora*. But though we cannot deny these facts, yet we think it improbable that *Carterina* should be united with the *Stylasteridæ* instead of with the *Cœnostromidæ*, as just the most important point of its organisation, the distribution of the larger tubes and canals, is so absolutely identical with that occurring in *Cœnostroma* that the real affinity with the latter genus cannot be mistaken, and its position in the *Cœnostromidæ* becomes absolutely necessary.

The genus is represented in the Salt-range by a single species—*Carterina pyramidata*. From other localities the genus has as yet not been reported.

1. Carterina pyramidata, Waagen and Wentzel, n. gen. et sp., Pl. CXVII, fig. 2, Pl. CXVIII, fig. 1, and Pl. CXX, fig. 3.

The general form of the hydrophyton is massive and apparently reversedly conical, though we are not quite certain what the natural position of the specimen may have been. We place it so that the pointed end of the conical mass is below, and we believe that it was fastened by this end to the bottom of the sea. The reversedly conical shape is, however, very irregular, the apex being bent to one side.

The natural surface seems to be nowhere quite intact, being everywhere deteriorated by weathering. As it is, the surface is strongly undulating and even lamellose on the lateral parts of the conical mass, and is entirely covered up by rock matter at the base of the cone, where however the specimen is terminated by a fracture, and not by the natural surface. The wrinkles on the lateral faces are approximately concentrically arranged round the apex.

If examined with a very strong lens, or with low magnifying powers of the microscope, the surface appears partly covered with round star-like openings, partly with winding canals, both different aspects of the calices, or tubes, into which the zooids were able to retract. These tubes open for the most part on the upper fracture of the specimen, but on account of their irregular bending some also open on the lateral surfaces, and are then also seen sideways on the upper fracture.

These calices are quite irregularly distributed and are never arranged in anything like regular groups, as is the case in the recent *Milleporæ*.

The most peculiar feature of these tubes is the existence of trabecular pseudosepta, which give to the whole a quite singular appearance. They are mostly to the number of seven to eight all round the tubes and bear a little thickened point at their terminations. They are rather regularly distributed in the vertical, as well as in the horizontal direction, and united together all along the outer limits of the tubes by trabecular parts of the skeleton. The spaces left between them are, however, rather large, and thus in microscopical section it mostly happens that not the pseudosepta, but the spaces between, are cut.

We have given on Pl. CXVIII figures both by reflected and by transmitted light. It must, however, be remarked that the colouring of the different parts is just the reverse in the different modes of light: what appears white in reflected light is all black in transmitted light, and *vice versâ*. This must be well remembered for the right understanding of our figures.

Fig. 1 *a* is a part of the upper fracture of the specimen as seen in reflected light. A little below the centre of the figure one sees several of the calices cut transversely and exhibiting very clearly the pseudosepta. Towards the margin of the figure several of the tubes are cut longitudinally, and one sees distinctly that one central tube is surrounded by several sloping ones. The large hole filled with grey matrix is either the work of some boring animal, or perhaps corresponds also to the "cavity or ampulla of a male gonophore," as occurs in the recent *Sporadopora*, as figured by Moseley, a copy of which figure we have given, Pl. CXXI, fig. 2. Fig. 1 *d* is a part of the lateral surface, also seen in reflected light, showing several tubes cut longitudinally. In both these figures the trabecular parts of the skeleton appear black, whilst the matrix filling the spaces between the trabeculæ and occupying the place of the cœnosarc shows a whitish colour.

Figs. 1 *b* and *c* are microscopical sections as seen by transmitted light. One represents a transversal, the other a longitudinal section. In both, the pseudosepta do not fall within the plane of the section. The trabecular parts of the skeleton are white, whilst the matrix appears black or grey and granular. None of the calices

is cut quite straightly across, but in fig. 1 *b* at the left hand upper corner, a central and two sloping tubes are seen very distinctly on the point of uniting. The same is seen in Fig. 3, Pl. CXX, a microscopical section in transmitted light showing a central tube cut obliquely and three of the radiating canals uniting with it. In all these sections drawn by transmitted light, the quite black round spots indicate cœnosarcal canals cut transversely by the plane of the section.

If very strong magnifying powers are employed, the substance of the trabeculæ appears as if intersected in all directions by dark lines. Traces of these can be seen in different places on our figures. We have satisfied ourselves that these lines are nothing but fine cracks, produced in the preparation of the sections within the sparry substance of the trabeculæ.

The measurements are as follow:—

Height of the hydrophyton so far as preserved, about	80·0 mm.
Greatest transverse diameter	85·0 „
Width of the vertical tubes	0·25— 0·3 „
„ radial canals	0·2 — 0·25 „
Diameter of the cœnosarcal canals	0·03— 0·1 „
„ „ ampulla-like enlargements	0·07— 0·13 „

Locality and geological position.—The only specimen of this species preserved in the Salt-range collection was found in the middle Productus-limestone of Chidru.

Remarks.—The fossil that has been described by us here under the name of *Carterina pyramidata* shows so very singular characters that it is barely possible to compare it to any other form described up to the present. There are some things bearing a distant similarity, but this is certainly only superficial and does not imply a real affinity of them to our species. There is, for instance, *Heliolites dubia*, Fr. Schmidt, from silurian strata, as figured by Dybowsky, which on a first glance seems to be somewhat similar to the Indian fossil, as also in this species the pseudosepta are of a trabecular nature, rather far distant from each other and separated by intervals of a rounded outline, and also bearing a rounded knob at their terminations, so that in transverse sections the tubes of this *Heliolites* look nearly identical with the calices of our *Carterina pyramidata*. But on a closer examination one finds that the walls of the tubes of that *Heliolites* are solid, and that there exists no trabecular skeleton, so all comparison ceases.

To similar results one comes also in other cases, and one must admit that *Carterina pyramidata* is a quite singular fossil which bears only family similarities to the *Cœnostromids*.

Genus: DISJECTOPORA, Waagen and Wentzel, n. gen.

Hydrophyton massive, of not very large dimensions, composed of trabeculæ, which partly form a regular network, partly are irregularly arranged. At the points of intersection they are thickened, and on the surface these thickenings often project as little knobs. If a regular network prevails, the horizontal trabeculæ form distinct zones, whereby a concentric lamination of the whole skeleton is produced. Between these trabeculæ canals extend, which also either form a regular network

of the same description as that produced by the trabeculæ, or are irregular according to the distribution of the trabecular mass. These canals show ampulla-like widenings at the points of intersection and are on the whole of a roundish outline; in the living state they contained the cœnosarc.

In this network composed of trabeculæ and the intervening canals, larger tubes are imbedded which served for the reception of the zooids. They are tolerably straight, not very strongly bending, arranged very irregularly and not numerous. Their width is about twice that of the cœnosarcal canals. At intervals these tubes send off horizontal canals in radial directions, but at different levels; they are not much narrower than the tubes themselves. It cannot be made out whether the canals belonging to one tube directly unite with the other adjacent vertical tubes, or whether a communication is only effected by means of the cœnosarcal canals.

The vertical tubes are in their transverse section rather irregular, not round, and change readily in shape, as the cœnosarcal canals open into them from different directions. At intervals the tubes are traversed by tabulæ which are apparently not quite of a trabecular nature, but somewhat more solid.

From this description it appears that the present genus is rather nearly related to the living *Millepora*, and in fact the relation is so very close that we for a long time were in doubt whether we should not regard the present form as directly forming part of that genus. The chief similarities consist in the vertical tubes being provided with distinct tabulæ, and sending off horizontal canals at different levels; these however do not merge directly into the tubes in *Millepora*, as they do in the present form. Though these similarities exist, we have yet decided not to place the present form too closely near *Millepora*, but to remove it even altogether from the family and to put it in the *Cœnostromidæ*. The reasons for thus proceeding are, that the tubes of *Disjectopora* are not arranged in groups; that there exists no difference in size between the tubes containing the mouthed and those destined for the reception of the mouthless zooids; and, lastly, the conditions of the trabecular skeleton, which forms for the most part a regular network, as generally occurs in the fossils hitherto considered as forming the family of the *Stromatoporids*, and not a network exactly similar to that occurring in the recent *Milleporæ*. These peculiarities seemed to us sufficient to indicate a systematic position of the fossils totally different from the *Milleporids*, whilst they all are such as generally occur in the fossils belonging to the family *Cœnostromidæ;* we accordingly felt justified in considering the genus *Disjectopora* as forming part of that family.

In the Salt-range the genus is represented by a single species, *Disjectopora milleporæformis*. As far as is as yet known, the genus has not been observed to occur at any other locality.

1. Disjectopora milleporæformis, Waagen and Wentzel, n. gen. et sp., Pl. CXVII, fig. 1.

The hydrophyton forms apparently a reversedly conical mass of not very large dimensions. It is, however, difficult to decide what may have been the original

position of the fossil, as the broad part of the cone is occupied by a plane of fracture, and the calices which served for the reception of the zooids open also everywhere on the lateral faces of the cone. Nevertheless it has somewhat the appearance as if the blunt apex of the cone bore something like a place of insertion, by which the whole hydrophyton was attached to a foreign body, and therefore we consider that the apex was below, and the broad part of the cone above.

The natural surface of the specimen is partly well preserved on the lateral faces, whilst it has entirely disappeared at the upper termination. As far as the surface is preserved, it shows a more or less regular network of trabeculæ interrupted from time to time by a compact epidermal tissue, of which it is, however, not quite certain whether it is an original feature, or of a secondary origin produced by the process of fossilisation (Pl. CXVII, fig. 1 *c*). The trabeculæ themselves have somewhat suffered by the process of weathering at the surface, and consequently appear there much thinner in general than they do in the interior of the specimen when seen in microscopical sections. We have figured in Pl. CXVII two different parts of the surface. One of them shows a rather regular net-work, in which horizontal and vertical branches of the trabeculæ can be clearly distinguished, whilst the other shows a quite irregular net-work, where such a distinction is impossible. In both pictures, chiefly in the latter one, numbers of calices are distributed; but on account of the alteration the surface has suffered by the process of weathering, the distinction is rather difficult. We consider the larger of the holes circumscribed by the trabeculæ as calices, that is, as entrances to the tubes into which the zooids were able to retreat. These calices are in these cases but little distinct from the remainder of the cœnosarcal tissue; in microscopical sections, however, where the tissue has not been altered, the distinctness is easily traceable (Pl. CXVII, fig. 1 *f*).

The trabeculæ thus exposed at the surface show several peculiarities. First we see that at the points of intersection, where several branches of the trabeculæ meet, they are considerably swollen; partly there even appear at these places small prominent knobs or obtuse spines (Pl. CXVII, fig. 1 *d*). In the same figure we also see that of the trabeculæ which radiate from the points of intersection in all directions, all the branches are not joined to other branches of an opposite direction, some remain free and extend within the meshes of the trabecular net-work.

In microscopical sections, of which we have made several, the trabecular part of the skeleton shows two peculiarities; first, that the central parts of the single trabeculæ are often differently coloured from the peripheral parts, and second that often a strange mode of preservation obtains, which either altogether obliterates the trabeculæ or at least changes them considerably in aspect.

As regards the first of these peculiarities, this very often gives the impression as if the trabeculæ were hollow, and traversed in the centre by a fine canal. After comparison of many sections, and after much painstaking, we arrived with perfect certainty at the conclusion that the trabeculæ were never hollow, and that this appearance was brought about by exactly the same circumstances as have been

observed by us on a large scale in the Monticuliporidæ, where the walls of the single corallites also seemed often as if traversed by a longitudinal canal, whilst this appearance was solely brought about by a singular mode of preservation. We are in consequence of this absolutely certain that hollow trabeculæ never occur.

The second peculiarity does not influence the description of the species, and therefore will be treated of later on.

The large tubes with their horizontal radiating canals have been described already above in the description of the genus. Their distribution is extremely irregular, as can be seen in Figs. 1 *e* and 1 *f*, Pl. CXVII. On the whole, it appears that their direction is approximately vertical in the centre of the specimen, and slowly bending laterally in the vicinity of the periphery. The tabulæ are not numerous, but apparently of a more compact nature than in other allied forms.

The measurements are as follow:—

Height of the hydrophyton as far as preserved	50·0 mm.
Greatest transverse diameter	58·0 „
Width of the vertical tubes	0·25— 0·33 „
„ „ radial canals	0·2 — 0·25 „
Diameter of the cœnosarcal canals	0·1 „
„ „ ampulla-like enlargements	0·1 — 0·13 „
„ „ trabeculæ	0·1 „

Locality and geological position.—There is a single specimen of this species in the Salt-range collection; it was found by Mr. Wynne in the middle Productus-limestone of Morah.

Remarks.—The specimen here under description shows a very peculiar preservation, inasmuch as its real structure is visible only at certain places; at other places, on the contrary, the real structure has been entirely obliterated and has given place to a kind of mock structure which might very easily be misleading. In fig. 1 *e*, Pl. CXVII, we see at both ends and in the middle of the figure certain places in which not a trace of trabeculæ can be made out, but where only meandering black lines can be distinguished. Such a spot has been represented, more strongly magnified, in Fig 1 *g*. One sees in this figure that here the skeleton has been transformed into one compact calcareous mass in which ferruginous parts, probably occasioned by the presence of the organic matter, have been secreted. These secretions may once have had some relation to the distribution of the solid skeleton; but as they appear now such a relation can no longer be made out, and thus we have a quite irregular distribution of ferruginous particles, partly grouped together in meandering lines, partly in isolated spots which allow of no conclusion as to the original condition of the fossil. Had the whole mass of the specimen been subject to a similar process of transformation as we see appear now in certain isolated places, a proper determination of the fossil would have been absolutely impossible.

The first beginning of this mode of preservation is represented by the dark lines, traversing the substance of the trabeculæ in different parts of the same figure (1 *e*) and giving somewhat the impression of dark canals.

The species is most nearly related to *Millepora alcicornis* of our present seas, but we have stated already above why it should neither be considered as forming part

of the genus nor of the family. To other forms, recent or fossil, the present species is much less nearly related, and we know of none to which it could be more closely compared.

Genus: IRREGULATOPORA, Waagen and Wentzel, n. gen.

Hydrophyton massive or lamellar, composed of a finely trabecular skeleton, in which larger tubes, some vertical, some horizontal, are imbedded.

The trabecular part of the skeleton is very irregular, the trabeculæ themselves very thin, and the canals between so much the larger. Neither the trabeculæ nor the cœnosarcal canals form a regular network, both being quite irregularly distributed. The canals very often show ampulla-like widenings at the points of intersection.

A concentric lamination or stratification is also absent.

The larger tubes, which have served for the reception of the zooids, are also very irregularly distributed. They are three to four times as wide as the cœnosarcal canals, and open everywhere on the surface of the hydrophyton. They are sometimes traversed by trabeculæ which are either single or in groups, and have probably the functions of tabulæ. The transverse section of these tubes is also very irregular; they are only very indistinctly marked off from the cœnosarcal tissue. On the whole they are more or less round, but in the single microscopical transverse section this round shape is more or less obliterated by the numerous cœnosarcal canals which enter the tube from all sides, and are not distinctly marked off from the tubes, properly speaking.

Between these vertical tubes, that served for the reception of the zooids, there extend irregularly horizontal tortuous canals of about the same width as the tubes, not traceable to any of the vertical tubes, but winding between them to and fro, and being in connection with the tubes solely by the cœnosarcal canals. In this respect they remind one much of the similar canals that have been figured of *Millepora* by Moseley, which figure we have copied for comparison's sake on Pl. CXXI, fig. 3 *a*. The whole arrangement is only much more irregular in *Irregulatopora* than in *Millepora*. These tubes can be seen in our fig. 2 *c*, Pl. CXVIII at different places. They are, however, exposed only for short distances within the section there figured, as they bend in the horizontal direction, and thus fall only for short distances within the plane of a section.

From this description it appears that the present genus is about as nearly related to *Millepora* as to the preceding one, or perhaps still more closely. This is chiefly expressed in the distribution of the horizontal canals, which are isolated, not merging directly into the vertical tubes, but connected with them only by means of cœnosarcal canals; they are not arranged in any way radially round the tubes. This arrangement of the horizontal canals is almost exactly as in *Millepora nodosa*, only that it is far more irregular in the present genus, and consequently a distinction between the horizontal canals and the vertical tubes is much more difficult.

Though, thus, in this respect the relation between *Irregulatopora* and *Millepora* is very close, there are on the other hand considerable discrepancies.

In the first place, these so-called horizontal canals are not, properly speaking, horizontal. They do not extend approximately in one plane, as is the case in *Millepora*, but bend irregularly up and down. While thus by these canals in *Millepora* an indistinct concentric stratification of the skeleton is produced, not a trace of such stratification can be observed in the present genus. The trabecular skeleton is far more irregular than in *Millepora*, and thus the whole forms a porous mass of very irregular tissue. In the tubes of *Millepora* rather compact tabulæ are developed, whilst in *Irregulatopora* these are replaced by trabeculæ, either singly or in groups.

Thus we see that in the present genus great similarities to *Millepora* go hand in hand with as great discrepancies. Notwithstanding this near affinity to *Millepora*, we have decided on placing the present genus in the family *Cœnostromidæ* rather than in the *Milleporidæ*, chiefly on the grounds of analogy with other forms, especially with *Disjectopora*.

The points of discrepancy between *Irregulatopora* and the *Milleporidæ* consist chiefly in the arrangement of the calices, which are not placed in groups; in the absence of a difference in size between the calices of the mouthed and mouthless zooids; and in a greater irregularity in the arrangement of all the parts of the hydrophyton.

Among the *Cœnostromidæ* the present genus forms certainly the most strongly deviating type.

Of the forms belonging to this latter family, the genus *Disjectopora* described above, is most nearly related to the present genus. The differences between *Irregulatopora* and *Disjectopora* are, however, rather obvious. The skeleton, which forms a tolerably regular network in *Disjectopora*, is quite irregular in *Irregulatopora*. The tubes for the reception of the zooids are irregular in their arrangement, as well as in their direction, and are apparently not in direct connection with the horizontal canals, which are at the same time very large and irregularly bending in the latter genus, whilst all this is not the case in the former. So it seems that the two genera are easily distinguishable from each other, whilst their affinity on the other hand is so great, that both must very likely be placed in one and the same family.

The genus has been found up to the present only in the Salt-range, and is there represented by a single species, for which we introduce the name *Irregulatopora undulata*.

1. Irregulatopora undulata, Waagen & Wentzel, n. gen. et sp., Pl. CXVIII, fig. 2.

Hydrophyton lamellar, or somewhat irregularly cup-shaped. Upper surface alone exposed, undulating but otherwise smooth, not rugged as in the two preceding

genera and species, finely porous. The calices can only be distinguished with difficulty; they are strewn all over the surface, but very irregularly distributed. The trabecular skeleton only distinguishable with a powerful lens, very irregular, showing nowhere any attempt at forming a regular network.

The dimensions of the hydrophyton are rather considerable.

The real structure of the specimen can only be recognised in microscopical sections. One can then observe that the substance of the hydrophyton is built up of a trabecular skeleton, in which the substance of the several trabeculæ is rather irregular in thickness, but generally comparatively thin. They leave room between them for canals, which are considerably thicker than the trabeculæ and which are chiefly characterised by round ampulla-like widenings occurring at all points where several branches of these canals meet. In these canals the cœnosarc was enclosed. They are altogether vermicular in their arrangement.

In this trabecular skeleton two sorts of larger tubes are inserted, but are only distinguishable with difficulty. The most important of these are the so-called vertical tubes, which open as calices on the surface of the specimen. These are best seen in the vertical section, represented Pl. CXVIII, fig. 2 *d*, where they are cut longitudinally. Some of them are nearly straight, others bending very irregularly; the preservation of the specimen is, however, not sufficiently good to follow them for any greater extent. They are often, and very irregularly, traversed by trabeculæ. In fig. 2 *c*, which is a horizontal section, parallel to the surface, several of these tubes are cut transversely. Also here they appear very irregular in every respect. Some of them appear larger, some narrower, some of them are more oval, others more circular, all are very indistinctly circumscribed, because of the circumstance that so many of the cœnosarcal canals open into them that the outline of the tubes themselves is nearly obliterated. Another cause of this indistinctness are the several trabeculæ which traverse the tubes obliquely, and thus happen sometimes to be cut transversely just in the middle of the tubes.

In the same figure there appear between the more roundish tubes, cut transversely, strongly elongate winding black bands, representing the so-called horizontal canals. These also are very indistinctly defined, as countless cœnosarcal canals open into them. We see that these canals are nowhere in direct communication with the tubes, but are joined to them only by the narrow cœnosarcal canals.

The measurements are as follow :—

Greatest length of the lamellar hydrophyton	52·0 mm.
„ breadth	46·0 „
„ thickness	12·0 „
Width of the vertical tubes	0·5—1·0 „
„ „ radiating canals	0·5 „
Diameter of the cœnosarcal canals	0·1—0·15 „
„ „ ampulla-like widenings	0·1—0·2 „

Locality and geological position.—The only specimen of this species existing in the Salt-range collection was found by Mr. Wynne, Trans-Indus at Bilot, in the middle Productus-limestone.

Remarks.—Also in this species, as in the preceding one, the preservation causes some difficulty in the attempt to interpret the pictures one sees under the microscope. The specimen, after its deposition in the rock, has evidently been infiltrated with much calcareous matter, which so intimately united with the calcareous trabeculæ that a distinction is no longer possible. We thus find that great parts of the fossil are composed of nothing but a compact mass of limestone, which, in the sections prepared for inspection, become generally traversed by numerous little cracks, which form a fine reticulation that could easily be misleading. In our figures 2 *c*, *d*, of Pl. CXVIII, these fine reticulations can be everywhere observed within the substance of the calcareous parts, and it must be borne in mind that they are nothing but cracks, and not structural features.

There is but little else to be remarked. The species is, in its general structure, not very far distant from *Disjectopora milleporæformis* described above. However, already the outward appearance of the entire hydrophyton suggests the idea that the two are specifically different. The whole shape is reversed, being conical in the one, and more or less lamellar in the other. The surface is rugged in the first, and smooth, only slightly undulating, in the second of the two species, and thus, even if the generic differences were not present, the two had to be considered as different species.

Of other forms none is known to us which could be compared more closely with the present species. As in its general appearance *Irregulatopora undulata* has much similarity to some forms of sponges; something allied to it may have been described under that head, but we are not aware of it, as the intimate structures of such things are only partly known.

Sub-Order: TUBULARIÆ.

Family: *SPHÆRACTINIDÆ*, Waagen & Wentzel.

The forms belonging to this sub-order are chiefly different from those of the preceding sub-order; in that the essential parts of which the hydrophyton is built up are little stolon-like tubes, which form a network, and from which the different sorts of zooids are developed. These tubes are mostly chitinous or of a horny substance, and it is doubtful whether they ever are built up of calcareous matter. The spaces between these tubes are filled with laminar expansions, either of a horny or of calcareous substance, which expands at intervals into little cones or spines, containing in their cavities the so-called skeleton zooids of Grobben.

The stolonal tubes are often of a boring nature, penetrate the calcareous substance of shells, and slowly dissolve the calcareous matter altogether.

The lamellar expansions extend in concentric layers, one supported on the spines of the other, thus forming a concentric laminated mass, which in a vertical section appears to form an irregular network.

In fossil forms, it seems the stolonal tubes are never preserved, and thus it becomes doubtful whether they were ever of a calcareous nature. The impressions of them, however, are visible in fossil species, forming furrows composing hexagonal meshes on the surface of the hydrophyton, which give to the whole a very characteristic appearance. These furrows are, however, characteristic only of certain forms, whilst in others they are apparently absent, and in these we have no signs of the former existence of stolonal tubes, though they may have been present. Nevertheless, as these stolonal tubes are just the most important part of the hydrophyton of the *Tubulariæ*, the zooids always taking their origin from them, the systematic position of the forms in which the former existence of such stolonal tubes cannot be proved, must remain somewhat doubtful; such forms at least cannot be directly united with *Hydractinia* and its allies, which have the stolonal tubes most distinctly developed.

In former days, when all the *Stromatoporidæ* and similar things were considered as more or less nearly related to *Hydractinia*, a more close distinction between the several forms was not necessary; but now, after we have recognised that a great part of these fossils could not be compared to *Hydractinia*, but were rather nearly related to *Millepora*, the remaining forms must also be subjected to a more close scrutiny, in order to learn how far the old opinion as to their affinity to *Hydractinia* can still be sustained.

We regret to say that the materials in the Salt-range collection belonging to this latter group are very limited, and did not admit of any accurate judgment as to the real affinities of these forms. We, therefore, are unable to advance any definite opinion as to the real systematic position of these things, or to add anything really new to our knowledge of them. Only so much we are able to state, that in a certain number of fossil genera every trace of the former existence of stolonal tubes is absolutely wanting, whilst in others at least the impressions of such can be observed. The affinity of the latter to *Hydractinia* is above any doubt, but whether the former are rightly placed in this vicinity must remain doubtful. According to Mr. Steinmann's indications, this possibility is, however, not excluded, and thus we let them remain in this position with all reserve.

The two groups, however, must certainly be made apparent, and thus we distinguish two families, the one of which bearing stolonal tubes will contain *Hydractinia* and its allies, the other without distinct stolonal tubes, we create to receive *Sphæractinia* and similar forms. We thus have—

I. Family: *HYDRACTINIDÆ.*

Hydrophyton, horny or calcareous, consisting of stolonal tubes connected by lamellar expansions in successive layers; between these layers hollow interlaminar spaces; surface with larger and smaller spines, between which furrows extend.

1. Hydractinia, van Beneden.—Always encrusting, only sometimes forming small branches; recent, and fossil in tertiary and cretaceous beds.

2. THALAMINA, Steinmann, 1878: Palæontographica, vol. XXV, p. 112, pl. XII, figs. 8, 9.—Hydrophyton more or less arborescent or polymorphous, consisting of laminæ which are partly vertical, partly horizontal, thus forming a network of more or less rectangular meshes. Structure otherwise very similar to that of *Hydractinia*. Typical species: *Thalam. cottaldina*, Orb. sp. The genus occurs not rarely in jurassic and cretaceous strata.

II. Family: *SPHÆRACTINIDÆ*, Waagen & Wentzel.

Hydrophyton always calcareous, consisting of concentric lamellæ supported on vertical pillars, which are sometimes also developed in a lamellar shape. Lamellæ and pillars are mostly pierced by more or less frequent openings. Stolonal tubes have not been observed up to the present.

The general outline of the hydrophyton is roundish, spheroidal, elliptic or cylindric.

1. SPHÆRACTINIA, Steinmann, 1878: Palæontographica, vol. XXV, p. 115, pl. XIII, figs. 3, 7.—Hydrophyton spheroidal. Surface of the lamellæ provided with tubercles on which rather large canals open; smaller pores are disseminated between them, the openings of which are placed on smaller tubercles. Vertical pillars mostly alternating regularly. Typical species: *Sphæract. diceratina*, Steinm. Jurassic of Stramberg.

2. ELLIPSACTINIA, Steinmann, 1878: Palæontographica, Vol. XXV, p. 116, Pl. XIV, Figs. 1—7.—Hydrophyton ellipsoidal sometimes branching. Concentric lamellæ of somewhat variable thickness, pierced by numerous pores on their surfaces sometimes with a network of grooves. Pillars very few, always oblique. Typical species: *Ellipsactinia ellipsoidea*, Steinm. From the jurassic deposits of Stramberg.

3. PARKERIA, Carpenter, 1870: Philos. Transact., Vol. 159, pt. 2, p. 721, Pls. 72-76.—Hydrophyton more or less spheroidal, on the whole somewhat similar to *Sphæractinia*, but the pillars are described as being hollow: cretaceous.

4. LOFTUSIA, Brady, 1870: Philos. Transact., Vol. 159, pt. 2, p. 743, Pls. 77-80.—Hydrophyton ovoid. Lamellæ not quite concentric, but more or less spirally arranged, on the outer side compact, on their inner surface traversed by labyrinthine canals, which are also present in the pillars: eocene of Persia.

5. STYLODICTYON, Nicholson and Murie, 1879: Journ. Linn. Soc., Zoology, Vol. XIV, p. 221, Pl. 3 figs. 1—3, non figs. 4—8.—Hydrophyton massive, having mastoid processes, in which the lamellæ are concentrically arranged, the centre of the processes occupied by reticulated tissue. Lamellæ and pillars traversed by numerous openings. Typical species: *Stylodict. retiforme*, Nich. and Murie. Devonian (Hamilton group) of North-America.

We have shown already that the two species subsumed by Nicholson and Murie in the genus represent two very far deviating types, of which the first, *Stylod. columnare*, Nich., according to the figures, appears to be something like *Labechia*,

whilst the second, represented by *Stylod. retiforme*, Nich. and Murie, belongs to the *Sphæractinidæ*. We have ignored here in a provisional manner the first type, as really intelligible figures of it do not exist, and have restricted the name to the second type, as the figures of this are well intelligible, pending better information.

6. Circopora, Waagen, and Wentzel, n. gen.—Hydrophyton cylindrical with rare lateral protuberances. Single lamellæ of a hemispherical shape supported on radial pillars of about the same thickness as the lamellæ. Both elements frequently but irregularly perforated. Typical species: *Circop. faveolata*, Waagen and Wentzel, n. gen. et sp. Middle Productus-limestone of the Salt-range.

These are the forms belonging to the sub-order *Tubulariæ* which have been found up to the present in a fossil state. We see that the family *Hydractinidæ* commences in upper-mesozoic times and extends from there up into the actual seas, where it has its greatest development. The family *Sphæractinidæ* commences already in the devonian epoch, has a single representative in permian times, and finds its chief development in mesozoic strata, where not less than three genera exist, to be at last extinguished in the lower tertiary beds.

In the Salt-range only the family *Sphæractinidæ* is represented by a single genus.

Genus: CIRCOPORA, Waagen & Wentzel, n. gen.

The general shape of the hydrophyton is elongated, more or less irregularly cylindrical, provided at intervals with large rounded blunt tubercles which apparently sometimes develope into short lateral branches. The upper termination was probably hemispherical, whilst the lower end was apparently more or less pointed, whereby the general shape in smaller specimens becomes also very elongately reversedly conical.

The skeleton consists of a series of numerous hemispherical lamellæ, all arranged concentrically in the direction of the longer axis of the hydrophyton. The convex side of the lamellæ is directed upwards, the concave side downwards. These lamellæ are connected together by numerous straight pillars or partitions, which are all vertical to the surface of the lamellæ. They are either narrow, and of equal thickness throughout, or they are somewhat broader and thickened at both ends, where they unite with the lamellæ, also somewhat of a laminar nature.

The lamellæ as well as the pillars are traversed by numerous pores, which are, however, very irregularly distributed. They are somewhat more numerous in the lamellæ than in the partitions, and are in the former position often united in groups.

The interlaminar spaces are very considerably broader than the laminæ and are subdivided in more or less rectangular or roundish chambers by the partitions or pillars. These chambers communicate with those above and below through the pores by which the lamellæ are traversed, but also laterally they are mostly in communication by the pores which traverse the partitions.

The skeleton is not always so regular as has been here described. Chiefly when one of the tubercles mentioned above is being formed, the concentric lamellæ begin to become irregular and suddenly bend out strongly, so that two systems of concentric lamellæ are slowly formed, bending round two different centres. Often also the partitions of several successive layers are placed approximately in the same position and direction, and then form long, more or less straight, continuous calcareous walls, which often traverse the skeleton for rather long distances. Other irregularities, which are also visible in our figures, cannot be satisfactorily explained. They are probably also due partly to preservation.

In our figures (Pl. CXIX, fig. 2 *a*, *b*. and Pl. CXX, fig. 2 *a*, *b*.) we see also that the cut edges of the lamellæ as well as of the pillars often show a dark line in the middle. This dark line corresponds to a structure which very generally occurs in the corals proper, and which has been termed there the primordial wall.

The genus is rather nearly related to several of those genera which are enumerated above as belonging to the family *Sphæractinidæ*. There is *Sphæractinia* itself which must be compared. First, the general shape of the hydrophyton in both genera is different. Then, the structure is, on the whole, much more regular in Steinmann's genus that it is in the Salt-range form. The pores on the lamellæ are much more numerous in our *Circopora*, and are not placed on warts, as is the case in the jurassic fossil. Thus, the difference between the two genera is rather obvious.

Yet more nearly related than *Sphæractinia* is *Ellipsactinia*. In this genus also cylindrical forms of the whole hydrophyton appear, and sometimes an attempt is made towards the development of branches as in our fossil, but the internal structure is considerably different. The concentric lamellæ are much thicker, the partition walls or pillars much more scarce and always oblique, and the canals traversing the laminæ much scarcer and larger, so that also in this case the distinction is not difficult.

The genus is represented in the Salt-range by two species, which will receive the names of *Circop. faveolata* and *Circop. tubulosa*. In other parts of the world the genus has not yet been detected.

1. Circopora faveolata, Waagen & Wentzel, n. gen. et sp., Pl. CXIX, figs. 1, 2; Pl. CXX, fig. 1.

Hydrophyton irregularly cylindrical or very elongately reversedly conical, terminated at the upper extremity by a hemispherical outline, with the other end probably attached to foreign bodies.

Lateral surface of the hydrophyton rather rugged, apparently covered with a kind of epitheca, which has transverse irregular, but more or less parallel wrinkles, but on the whole very badly preserved. There are at intervals large blunt tubercles, the beginning of ramifications, which are, however, apparently never developed into real branches.

If the epitheca is worn off by weathering, as generally happens, the whole surface is covered with more or less parallel lines, all somewhat vaulted towards the upper end of the hydrophyton, and separated from each other by narrow furrows. These lines are the edges of the lamellæ of which the skeleton is composed, and which are on the whole of a hemispherical shape. They are connected together by vertical walls, which traverse the furrows, and thus form parallel series of little cells, to which the name ought to allude. This structure is, however, well visible only for short distances on the specimens that serve for description. Generally the action of weathering has worn away a more or less considerable part of the skeleton, and then this natural section is all covered with highly arched concentric lines, between which off and on the little cells can be distinguished.

At the upper extremity of one of the specimens the last terminal lamella is partly preserved, and one sees that the surface is rather smooth, without tubercles and provided with numerous fine pores, which are rather irregularly distributed and gathered here and there in irregular groups.

Otherwise there is but little to be said of the outward appearance of these things. They are mostly rather badly preserved, and their real structure can generally only be made out by microscopical sections.

In such sections one sees that the substance of the lamellæ is very thin and compact, often showing in the middle a dark line, a structural peculiarity which can often be observed in the different parts of the skeleton of the *Cœlenterata*. Horizontal and vertical sections do not look markedly different with regard to these lamellæ. They always form more or less concentrically arranged lines, according to their approximately hemispherical shape. In both cases we see that they are frequently perforated by small pores, in which case the cut edges of these lamellæ are resolved into dotted lines.

The partition walls, vertical lamellæ or pillars, as one also may call them, look on the contrary rather different in vertical and in horizontal sections. Chiefly they are not contiguous as are the concentric lamellæ; and though of a lamellar nature, they are mostly of very moderate extent. They are arranged more or less radially in a horizontal as well as in a vertical direction, and are generally vertical to the surface of the concentric lamellæ. In horizontal sections (Pl. CXIX, fig. 2 *a*) they generally do not traverse more than one interlaminar space, are very thin and of equal thickness for their whole extent and are joined at sharp right-angles to the substance of the lamellæ. Sometimes, but not always, they show perforations. In vertical sections (Pl. CXIX, fig. 2 *b*) they are, if possible, even still more irregular than in horizontal ones. For comparatively large distances they appear to be almost entirely absent, whilst at other places they are rather thick and traverse obviously four and five interlaminar spaces in succession. In other places again, these partition walls are restricted to a single interlaminar space. This irregularity is further augmented by the mode of perforation that prevails. There are often for long distances no pores at all, whilst in other cases, chiefly when the partition walls are

restricted to a single interlaminar space, pores are of regular occurrence, and there are even cases, where such walls are resolved into a series of dots.

Though this great irregularity prevails, yet the general arrangement of the different parts of the skeleton can be deduced with sufficient certainty from the facts ascertained from the microscopical sections.

The measurements of the specimens at our disposal are as follow:—

Entire length of the hydrophyton unknown.	
Greatest thickness	15 to 18 mm.
Width of the interlaminar spaces	0·21 „ 0·28 „
Thickness of the lamellæ	about 0·07 „

Locality and geological position.—There are altogether two specimens of this species preserved in the Salt-range collection, which were both found by Mr. Wynne in the middle Productus-limestone of Morah.

Remarks.—As regards the preservation of these fossils, it must be remarked that, as in *Ellipsactinia*, so in the present species foreign bodies are very often enclosed in the substance of the hydrophyton and a part of the irregularities of growth are certainly caused by these.

It has already been stated above that the forms belonging to the genus *Circopora* bear a more or less close resemblance to *Sphæractinia* and *Ellipsactinia*, and this is chiefly in a high degree the case with the present species. *Sphæractinia* has similarly thin lamellæ, which on the whole are also rather similarly arranged. But whilst these lamellæ are pierced by numerous holes in our *Circopora faveolata*, they are nearly compact in Steinmann's genus, and canals or holes piercing the lamellæ are only rarely to be observed, and thus the similarity is only an apparent one. Quite the same is the case with *Ellipsactinia*. Here the similarity is yet a more distant one. The lamellæ are much thicker, of an entirely different structure, and the partition walls are very rare and always strongly oblique. The perforations of the lamellæ, on the contrary, are similar in both fossils.

With regard to other forms, as *Parkeria* or *Loftusia*, there also exists a certain similarity, which is however only quite surperficial.

2. Circopora tubulosa, Waagen & Wentzel, n. gen. et sp., Pl. CXX, fig. 2.

Hydrophyton irregularly, elongately, cylindrical; not quite straight but variously bending; provided at intervals with blunt tubercular processes, giving the impression of a commencing ramification. Upper end hemispherically rounded; the lower extremity is not preserved.

Lateral surface of the hydrophyton very rugged, bending out and in the most irregular manner, but not sufficiently well preserved to observe whether an epitheca was present or not.

If the surface is somewhat worn, the same lines appear as have been described in the preceding species, but everything is of a coarser nature. The substance of

the lamellæ is much thicker, and their distances much larger. Otherwise they are similarly arranged. If the weathering only just touches the surface, the lines appear more or less straight, though rather irregular. If the weathering proceeds deeper, the lines become more and more vaulted, until towards the centre they are semi-circularly arched. The lamellæ are connected together by partition-walls or pillars, which cause a reticulated appearance of the weathered surfaces.

The surface of the uppermost terminal lamina cannot be observed, as it is covered up by rock matter.

The true characters of the species can only be recognised in microscopical sections. We have figured such sections on Pl. CXX, fig. 2 *a*, *b*, of which fig. 2 *b* is a horizontal and fig. 2 *a* a vertical section. We see at once in these sections that the solid parts, forming the skeleton, are rather robust, and exhibit generally not straight, but to a certain extent rounded outlines ; this is caused by the circumstance that the median portion of each single part of the skeleton is attenuated, whilst both ends are more or less swollen, whereby rounded pores and canals are circumscribed, quite different from those described in the preceding species. The lamellæ forming the concentric layers, of which the whole skeleton is composed, are well distinguishable in both sections. They are of tolerably equal thickness for longer distances, often traversed by pores and frequently joined by partition-walls, which are strongly broadened at the points of junction and considerably attenuated in the middle. Also there appears often in the middle of these hard parts a dark line or else a dark mark, which is caused either by structural peculiarities or by a singular mode of preservation, but never indicates the existence of fine canals in the centre of these parts.

The interlaminar spaces are of considerable width, but rather irregular in their extent, often interrupted or displaced, but on the whole following a concentric arrangement. The partition-walls or pillars are still far more irregular, and often absent for longer distances. At other places they are again more numerous, and then often continued through a series of successive interlaminar spaces. They are not perforated by pores so frequently as the lamellæ. Where their distribution is somewhat more regular, rounded canals or chambers are partitioned off by them, which acquire a nearly circular outline by the singular development these partition-walls have attained.

In the horizontal section (Pl. CXX, fig. 2 *b*) one sees a number of successive concentric lamellæ which show there a singular diverging arrangement, which is caused by the circumstance that the figure represents that part of a section where one of the external tubercles is just on the point of developing. Between these concentric lamellæ the partition-walls or pillars extend here in a tolerably regular manner and circumscribe nearly circular canals or chambers.

In the vertical section (Pl. CXX, fig. 2 *a*) which is taken not far from the centre of the hydrophyton, the interlaminar spaces appear much wider, and interrupted by but few partition-walls, which are partly incomplete. Towards the right of the figure the skeleton becomes irregular on account of the intrusion of a foreign body (Dybowskiella).

The measurements are as follow :—

Entire length of the hydrophyton unknown.	
Greatest thickness	21·0 mm.
Thickness of the concentric lamellæ	0·1—0·12 „
Width of the interlaminar spaces	0·4—0·5 „

Locality and geological position.—The only specimen of this species, preserved in the Salt-range Collection, was found by Mr. Wynne in the middle Productus-limestone of Morah.

Remarks.—As in the preceding species so also in this one, the regular growth of the hydrophyton is often interrupted by foreign bodies that are included in the substance and have been overgrown by the colony. In this respect a certain similarity to *Ellipsactinia* cannot be denied, but whilst in Steinmann's genus these foreign bodies do not influence the growth of the whole hydrophyton, in the present form this influence is rather considerable, as appears from our figures.

The nearest relation of the present species is beyond doubt the species previously described under the name of *Circop. faveolata*, W. and W. The external shape of the two species is nearly identical, and it would be impossible to distinguish between the two; but in microscopical sections a difference would soon become apparent. In fact, in the intimate structure the two forms are as different as they are similar in external appearance. If we compare the microscopical sections of the two species, drawn on Pl. CXIX, and Pl. CXX, we see immediately that this difference chiefly lies in the different structure of the skeleton. Every part of this species is more robust than in the preceding one : the thickness of the concentric lamellæ is 0·1 to 0·12mm. in *Circopora faveolata*, the same is 0·6 to 0·8mm. in the present species. The interlaminar spaces, which are 0·21 to 0·28mm. in the first species, are 0·4 to 0·5mm. in the present one ; this difference is so considerable that on weathered surfaces it can be observed even with the naked eye or with a common pocket-lens. But also the shape of the different parts of the skeleton shows considerable differences. The partition-walls, or pillars, are considerably broadened at the points of junction with the concentric lamellæ, and thus circumscribe round holes or tubes, to which circumstance the name *Circopora tubulosa* is meant to allude. Thus, we see that the two certainly represent different species, but on the other hand they are also again so much in accordance with each other, that they certainly belong to one and the same genus.

There is, however, yet another fossil with which the present species must be compared; this is *Stylodictyon retiforme*, Nichols. and Murie. The transverse or horizontal section represented on Pl. III, fig. 3 of Nicholson and Murie's paper shows towards the centre similar rounded cells, but more towards the periphery this character soon disappears, and the whole becomes more similar to *Circop. faveolata*, though somewhat more irregular. On the whole there is no doubt a certain similarity of type between *Stylodictyon* and *Circopora*, but the reticulated tissue in the centre of the columns and the massive form of the hydrophyton in *Stylodictyon* make a generic distinction between the two absolutely necessary, and thus also the specific similarity between *Styl. retiforme* and *Circop. tubulosa* is only an apparent one.

SUPPLEMENT TO THE BRYOZOA.

Family: *PETALOPORIDÆ*, Waagen.

In the course of investigations regarding the corals of the Salt-range, we had occasion to study in detail two small fossils, which to all appearance belonged to the genus *Rhombopora* of Meek, and at first we took them to be corals. But after we had made several sections, as many as the very scanty material would allow, we soon found, that the mode of gemmation prevailing in these *Rhomboporæ* was not in any way similar to that occurring in the corals, but was absolutely identical with what we generally found to be the case in the *Bryozoa*; thus, we could not describe these two fossils among the corals, and having recognised them to be *Bryozoa* we are obliged now to give a supplement to this class for the description of these two little species.

After having shown the probability that a great many of the fossils formerly described under the names of *Cerioporæ* or *Heteroporæ* are in reality corals and not *Bryozoa*, it is impossible to employ either of these names any longer for the designation of a family composed of organisms belonging to the *Bryozoa*, so we are obliged to look out for another name.

There exists beyond doubt a group of forms among the *Bryozoans*, in which all the cells are not of the same size, but in which there occur so-called interstitial tubes between the larger cells. Among these forms the genus *Petalopora*, Lonsd., has been studied most in detail as to its mode of gemmation, and is shown beyond any doubt to belong to the *Bryozoans*. Thus, we have chosen this genus for the formation of a family name.

We comprise in this family arborescent colonies of *Bryozoans* in which small interstitial tubes are intercalated more or less frequently between the proper cells. All the cells take their origin in the centre of the branches and are there produced by gemmation, in the mode characteristic of *Bryozoans*. According to this definition the genus *Rhombopora* falls also within the scope of the family. It is represented in the Salt-range by two species.

Genus: RHOMBOPORA, Meek.

Meek characterises the genus in the following manner:—

"Small ramose corals, with non-septate short tubular cells, radiating obliquely outward and upward on all sides from an imaginary axis; cell-mouths rhombic or rhombic-oval, and very regularly arranged in longitudinal and oblique spiral rows, the former of which are sometimes separated by more or less flexuous longitudinal ridges; interspaces usually rather thick, and not pierced by transverse pores, but occupied by very minute non-septate longitudinal cells that are closed and represented at the surface by minute granules or spinules."

To this definition but very little need be added. It should be at once remarked that the present genus does not belong to the corals but to the *Bryozoa*, as is shown most clearly by Mr. Meek's own figure, where the longitudinal section most clearly exhibits the mode of gemmation prevailing in the latter.

As regards the little granules mentioned in Meek's diagnosis, it is worthy of notice that this is only a secondary character, caused by preservation, though it may be present in most species. The cause of this character is the accumulation of sparry matrix at the mouths of such very narrow canals, which often protrudes in hemispherical masses and is of very general occurrence in widely different fossils.

The genus *Rhombopora* is most nearly related to *Petalopora*, Lonsdale, but is distinct from it by the more or less regular arrangement of the cells in oblique rows, and by the absence of those longitudinal ridges which subdivide the surface of most species of *Petalopora*, causing an arrangement of the cells in more or less regular vertical rows.

The genus is represented in the Salt-range by two species, which are both new.

1. Rhombopora obliqua, Waagen, n. sp.

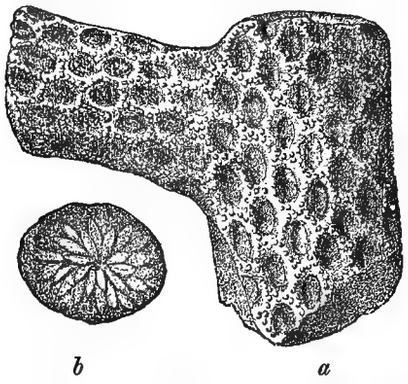


Fig. 31, Rhombopora obliqua, Waagen, n. sp. Specimen from the middle Productus-limestone of Kafirkot: (*a*) lateral view of the fragment; (*b*) transverse section of the lateral branch, badly preserved, both enlarged ten times.

The entire colony is arborescent, composed of small straight stems which bifurcate at intervals, and which have an approximately circular, or only very slightly compressed, transverse section. The thickness of the branches is 2 to 3 mm.

They are composed of short tubes, which originate in a single line in the centre and extend thence upward and outward. They are separated from each other by rather thick walls in which the interstitial tubes are imbedded. The latter are about ten times thinner than the other tubes.

The openings of the tubes on the surface are generally oval and arranged regularly in quincunx, so as to form very steeply ascending oblique rows. They are comparatively rather large, each of them about 0·25 mm. in the transverse, and 0·5 mm. in the longitudinal direction. There are five to seven cells within one oblique row.

The spaces between the cells are occupied by little granules, which surround the cells on all sides, and do not mark off very distinctly rhombic spaces; on the whole they are, however, arranged in single rows. The granules are made up of spary matter and indicate the position of the interstitial tubes. There are none more conspicuous than the rest by greater size or in any other way.

Locality and geological position.—The only fragment of this species in the Salt-range collection was found by myself in the middle Productus-limestone at Kafirkot (Trans-Indus).

Remarks.—The present species belongs to that group of forms which bear a rich ornamentation, and to which belong, of other species, *Rhomb. lepidendroides*, Meek, *Rhomb. interporosa*, Phill., and *Trematop. granulifera*, Hall, which is probably also a *Rhombopora*. The form which is most similar to the Indian fossil is the last of the three mentioned. It comes from the Niagara group of Indiana and has been described by Hall in the twenty-eighth Annual Report of the New York State Museum. It is distinct from the species here under description solely by the more sparingly distributed granules between the cells and by the more slender branches. This all, however, applies only to the outward appearance. The internal structure of the American species is not known, and it may well be that it is not a *Rhombopora* at all, but some form belonging to the *Monticuliporidæ*.

Next in similarity comes *Rhombop. interporosa*, Phill., from the mountain-limestone of Yorkshire. This species has much more slender branches, and the cells are much smaller, and comparatively further distant from each other.

Rhomb. lepidendroides, Meek, is much more regular in its sculpture, and the oblique rows of cells are much less steep.

2. Rhombopora polyporata, Waagen, n. sp.

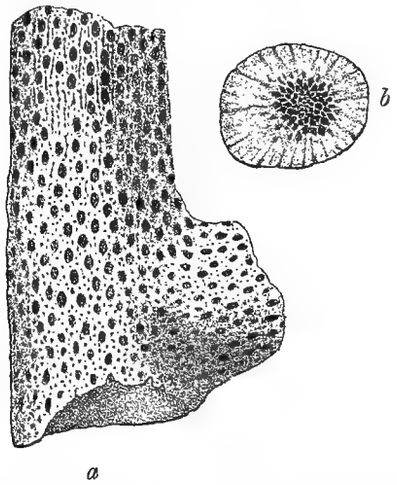


Fig. 32, Rhombopora polyporata, Waagen, n. sp. Fragmentary specimen from the topmost beds of the upper Productus-limestone of Virgal: (*a*), lateral view; (*b*), transverse section of another specimen, both enlarged ten times.

The shape of the entire colony is apparently arborescent, but only fragments are known to me. They represent small straight branches, which sometimes bifurcate. The transverse section is mostly not circular, but more or less oval or compressed, chiefly at the spots where a bifurcation takes place. The diameter of the branches is on an average 2mm.

The branches are composed of little tubes which originate at an imaginary axis, and diverge thence upward and outward. They are present in great numbers, and give to the branches somewhat the appearance as if belonging to *Geinitzella* or the like. But on a closer examination one soon finds, that the mode of gemmation is that characteristic of *Broyozoa*. The walls between the tubes are rather thick, and pierced by numerous very thin interstitial tubes.

The surface of the branches is remarkably smooth, without distinct subdivision into rhombic spaces, nor are there any granules surrounding the cell-openings.

The cell-openings are very small and of an oval shape. Their longer diameter is about 0·2mm., the shorter one 0·1mm. They are about their own diameter distant from each other. These distances are occupied by numerous interstitial pores, which are very fine, all of about equal size and generally arranged in single rows. The cell-openings are distributed rather indistinctly in quincuncx, so that more or less regular vertical and oblique rows can be distinguished. There are thirteen to fourteen such openings within one of the oblique rows.

Very rarely there occur a kind of maculæ, where no large openings are present, but the whole is occupied solely by interstitial tubes.

Locality and geological position.—There are two fragments of this species preserved in the Salt-range collection, which were both found by myself in the topmost beds of the upper Productus-limestone of Virgal.

Remarks.—This species also is again more or less nearly related to *Rhombop. interporosa*, Phill., as the entire arrangement of the cells and distribution of the pores between them is very similar in both species. On a closer comparison, however, one finds again that the branches are much more robust and the cells more numerous, as there are up to 14 cells contained in one oblique row. Another peculiarity consists in the circumstance, that the pores between the cells are in the present species often arranged in vertical rows, as in *Petalopora*.

From the species described above, the present one is distinct by the much smaller cells.

On the whole, it is remarkable how much the present species resembles a true *Petalopora*, and one might even be doubtful whether it should not be rather described in that genus. I have left it in the genus *Rhombopora* on account of the, on the whole, quincuncial arrangement of the cells and of the absence of vertical prominent ridges on the surface. It cannot, however, be denied, that this species forms to a certain extent a transitional link between the geologically older *Rhomboporæ* and the more recent *Petaloporæ*.

Class: AMORPHOZOA.

Order: PHARETRONES.

Sub-Order: SPHINCTOZOA.

Family: *SPHÆROSIPHONIDÆ.*

In treating of the present class of animals, we rather prefer to use the name of *Amorphozoa*, introduced by Blainville, than that of *Spongitæ* or *Spongiaria* applied by Grey, Fleming, or Milne-Edwards. The latter name seems to us too concrete, applying chiefly to the bath-sponges, whilst very many other and widely different things must also be included in the class. Then the name *Amorphozoa* is so very appropriate to the organisms here under consideration that it would be a pity that such an excellent name should not be made use of. Moreover, the name *Amorphozoa* is more in accordance with the names applied to the other classes of *Cœlenterata*, and *Amorphozoa*, *Hydrozoa*, *Anthozoa* sound very well together.

This, however, implies that we consider the *Amorphozoa* as belonging to the *Cœlenterata*. There are many reasons for doing so, as will be explained later on, but all, or most, of these are not so much founded on their general organization as on their minute structure; and it is well known, and has been adduced already by Steinmann, that the skeleton elements of certain *Amorphozoa* are astonishingly similar to those of the *Alcyonaria*.

If, however, they are *Cœlenterata* they are a very degenerate set, which have even altogether lost their stomach, the chief criterion of the *Cœlenterata*. The chimney-like cavity which is present in the centre of many forms can certainly not be considered as such, as it is only of accidental occurrence. This degeneration has been brought about by the fundamental mistake committed by these animals, that they attach themselves as *Gastrulæ* by the oval end of their body to foreign bodies, whereby the mouth and stomach could be of no further use to them and so became entirely obliterated. Naturally the animals must make up as best they can for this deficiency, but a real stomach they never attain. There is a cavity often developed on that end of the body opposite the mouth, and this cavity corresponds probably to the chimney-like cavity of certain forms; but as there is no real mouth there is no real stomach, the cavity serves only for the ejection of water, and the so-called osculum at the end of it must rather be considered as anus than as mouth.

The means of nutrition are probably chiefly effected by the numerous canals that traverse the body of these animals.

That in their essence these organisms are related to the *Cœlenterata* and only degenerate by quite abnormal circumstances, is shown partly by the mostly radial arrangement of these canals, by the similarity of the elements of their skeleton to

those of the *Alcyonaria*, and by the close approximation of certain forms to the Corals, as will be demonstrated later on.

It is impossible to begin the description of any form belonging to the sponges, without recurring to Zittel's most important papers on the structure of the animals belonging to this class.

Zittel in his Handbook distinguishes seven orders within the class; of which, however, only five have been found up to the present with certainty in a fossil state. The last of these is made up of the *Calcispongiæ*, of which the *Pharetrones* form only a family.

The living forms of the *Calcispongiæ*, which are found in rather great numbers in our present seas, are all characterised by a skeleton, which is made up numerous simple or three-radiate or four-radiate calcareous spicules, which are often packed together in great numbers, forming thick walls, which, however, always remain free and are never blended together, nor forming a meshwork, as in the *Hexactinellidæ*, nor in any other way.

The *Pharetrones* are a group of forms that occur in a fossil state only, and which possessed a calcareous skeleton, as is amply proved by Zittel's investigations; and by the more recent studies of Dr. Steinmann, who re-affirms Mr. Zittel's results in this respect in all details. Nevertheless, the structure of the *Pharetrones* deviates rather widely from that generally occurring in living *Calcispongiæ*, so much so that the opinion has been expressed, that they should not be considered as belonging to the *Amorphozoa*, but rather as some other form of the *Cœlenterata*, perhaps *Alcyonaria*.

The difference of all the *Pharetrones* from the *Calcispongiæ* consists chiefly in the circumstance that either spicules are of rare occurrence, or can at least not be distinguished, the entire walls consisting of a rather compact, perforated, calcareous mass; or if spicules can be distinguished in greater numbers, then they are blended together in different ways, but always forming a kind of fibres, in which they are either entirely or only partly imbedded.

Nevertheless, we are far from asserting that there existed no connection whatever between the *Pharetrones* and the recent *Calcispongiæ*. On the contrary, we believe that a line of continuous development can be established from the *Pharetrones* to the *Calcispongiæ*. This development manifests itself in several ways. First in the development of the spiculæ. In the palæozoic genera and species of *Pharetrones* only simple fusiform spicules occur; in the cretaceous species tri-radiate spicules are of frequent occurrence; and in the recent *Leucones* tri-radiate and four-radiate forms by far predominate. As the last remnant of the fibres of the *Pharetrones* is to be considered probably the plaster-like substance called "*Stäbchen-Mörtel*" by Häckel, occurring in the *Leucones*. Second, in the development of the canal-system. This is very simple in the palæozoic *Pharetrones*, more developed in the cretaceous ones, and of an extreme degree of development in the recent *Leucones*. Now we think it not quite impossible that the hard parts may have degenerated, the compact shelly parts and fibres being dissolved into spicules, in

favour of the development of the canal-system. Though all this may have been the case, the *Pharetrones* must yet have been in their general structure very far deviating from the recent *Calcispongiæ;* and the tissues that secreted the compact shelly layers and fibres in the *Pharetrones* must have been more similar to those of the corals than the tissues of the recent *Calcispongiæ*. It appears thus more or less doubtful if such a development could be termed a progressive one. It is only so in a certain sense.

The materials contained in the Salt-range collection (all *Sphinctozoa*) are tolerably extensive, though not representing a great number of genera and species, but, we regret to say, these materials are rather indifferently preserved, and the substance of the walls is always transformed into a sparry mass, in which it is impossible to distinguish any structure. Thus, we are not in a position to add many new facts to those already made known with regard to these organisms by Zittel, Steinmann, and Dunikowsky.

The latter has more recently treated in detail some of the *Pharetrones;* but, though his work is otherwise so excellent, it seems to us that with regard to the fibres he has caused the questions here at stake rather to be obscured than cleared up, as he considers the fibres of which the skeleton of the *Pharetrones* is generally made up to be secondary elements, produced only by the process of fossilisation.

Dunikowsky must admit that these fibres are of very general occurrence in the *Pharetrones*, and that there are no forms among the whole order in which they would be absent, and which would be composed of more or less free spicules. If the fibres were of secondary origin and produced only by the influence of the decomposing organic matter upon the calcareous spicules and the fossilising substances, it would be difficult to understand how in all cases the same effect was attained, resulting in the formation of compact fibres. According to Dunikowsky's views the fibres are really of inorganic nature and include only fragments of organic substance, *i.e.*, those parts of the spicules which have not entirely been dissolved. If this is the case, then it is very strange how the whole fibres have been replaced by silica in silicified specimens, as it is the rule in the process of silicification that only the organic tissues are replaced by silica, whilst all that is not organic remains of a calcareous nature. That the entire fibres are transformed into silica is amply proved by Zittel's own observations, and thus it becomes highly probable that they are of organic nature, and not of secondary origin. Besides this, there is sometimes a distinct structure distinguishable within the fibres, and sometimes even something like a primordial fibre can be observed comparable to the primordial walls in corals, and followed on both sides by secondary thickenings. From all this it becomes highly probable that the fibres are an original feature of the *Pharetrones*, restricted to the order and distinguishing it from all the rest of the *Amorphozoa*. Thus, though the skeleton elements of the *Pharetrones* are of a calcareous nature, yet these organisms cannot be placed together with the *Calcispongiæ* of our present seas.

The fibres of the *Pharetrones* are of very different development in the different forms: in some their original composition of spicules, melted together by organic

calcareous substance, is very conspicuous; whilst in others this composition almost entirely disappears, the fibres being transformed into porous calcareous walls or even into compact lamellæ, which in every respect can be compared to the lamellæ forming the vesicular tissue in corals.

The most remarkable forms in this latter respect have been described by Steinmann under the names of *Amblysiphonella*, *Sebargasia*, *Cryptococlia*, *Sollasia*, &c. This group is largely represented in the Salt-range, and we had good means for studying the structure of the skeleton. As in all the *Sphinctozoa*, it is composed of a series of hemispherical or shortly cylindrical pieces. Sometimes there is a central tube, sometimes not. Each piece has a thick strongly porous wall covering the peripheral and upper parts, and lining the central tube, if there is one. The lower surface remains free, and is occupied by the upper part of the wall of the preceding piece. In this manner a series of chambers is formed, and specimens in which a central tube is present are not unlike the shell of an *Orthoceras* with a wide central siphon. The chambers thus formed are filled with a very irregular vesicular tissue, not dissimilar to the vesicular tissue of some *Tetracoralla*, such as *Cystiphyllum*, *Strephodes*, &c., the single vesicles being chambered off by irregularly curving shelly lamellæ.

Regarding the finer structure of the elements of the skeleton, the outer wall is pierced by two sets of very numerous pores, larger and smaller, as in a sieve. The larger ones are easily perceptible with the naked eye, arranged more or less in quincunx; the smaller ones are extremely numerous, and well distinguishable with a common pocket-lens. The walls of the vesicles on the contrary appear, even if strongly magnified, as thin compact shelly lamellæ. So far no spicules have been detected by us within these parts of the skeleton. The rock, however, that surrounds these parts, often swarms with small, single, fusiform spicules, which have often a thorny surface, and sometimes have the central canal preserved. As spicules are not of very general occurrence in the calcareous rocks of the Salt-range, it is somewhat surprising to meet them here so frequently, and the supposition appears not very hazardous that these spicules were originally imbedded in the soft parts of the animals that also produced the other hard parts of these bodies.

The evidence of the features we have exposed up to the present is of a somewhat conflicting nature. The greater part, it must be confessed, is not entirely in favour of the opinion that these fossils should be considered as *Amorphozoa*, but the compactness of the hard parts and the existence of a vesicular tissue rather points to the conclusion of these organisms being real corals, perhaps *Alcyonaria*, as advocated by Steinmann, rather than *Amorphozoa*. On the other hand, there are some features which forbid their being placed with the true corals. This is chiefly the great porosity of the walls, which are like a sieve, and must have allowed a free percolation of the sea-water. We must admit such a supposition, as in forms with hemispherical pieces or segments the water would have had no access to the interior of the animals, the chambers being closed all round, except by these pores, and thus these cannot have been closed by organic matter. But then the body of these

Sphinctozoa must have been very differently constructed from that of real corals and must have been much more similar to that of the *Amorphozoa*.

Another feature that is not developed in the Indian materials, but which is otherwise of frequent occurrence, is the existence of numerous ostia on the surface of many forms, such as *Enoplocœlia*, Steinm., *Sollasia*, Steinm., *Celyphia*, Pomel, &c. These in connection with the central tube with its osculum, as in *Enoplocœlia*, give an appearance to these things so entirely amorphozoic that their real nature can barely be doubted.

To these features must be added the occurrence of spicules, either imbedded in the soft parts or forming part of the fibres.

All this taken together, the greatest probability seems to be that the *Pharetrones* are in reality sponges, though they cannot be united with the *Calcispongia* of our present seas, but deviate rather far from them.

On the other hand, it cannot be denied that they are rather nearly related also to the real corals, chiefly the *Alcyonaria*. This proves two things: *first*, that the *Amorphozoa* form most probably part of the *Cœlenterata*, and not of the *Protozoa*; and *second*, that the *Pharetrones* are the most highly organized of all the *Amorphozoa*, approaching in their structure very near the true corals, thus obliterating more or less the fundamental difference that exists in the development of corals and sponges, the former fixing themselves in the *gastrula* state by the closed ab-oral end of their body to foreign bodies, the latter doing the same by the mouthed end. Only later on, the latter develop at the opposite end a central cavity which is probably to be considered as morphologically different from the gasteral cavity of the corals. Nevertheless, it seems that both can develop into forms which approach each other very closely.

We thus may be justified in considering the *Pharetrones* as an order of sponges by themselves; forming to a certain extent a transitional link between sponges and corals, distinct from the first by a more solid skeleton and from the latter by perforated walls of the body allowing the sea-water to enter laterally.

Steinmann distinguishes among the *Sphinctozoa* four families, of which two, the *Sphærosiphonidæ* and the *Sphærocœlidæ*, are represented in the Salt-range.

Steinmann (Neu. Jahrb. f. Min. 1882, II. p. 163) characterises the family *Sphærosiphonidæ* in the following manner. The family is distinct from the "*Sphærocœlidæ* by the presence of a more or less perfect central tube, from the *Verticillitidæ* by the absence of a fibrous tissue filling the interior of the segments. Walls pierced by straight or but little curved canals; a central osculum present. Only *Enoplocœlia* is covered with a thick epitheca, which is perforated by a greater number of small ostia. Fibres of the skeleton, as far as their structure can be made out, consisting of long, slender spicules, without an axial canal."

To this definition we may perhaps add that in the forms of the Salt-range a vesicular tissue is present, occupying the interior space of the segments.

In the Salt-range only a single genus, belonging to the family, has been found up to the present.

Genus: AMBLYSIPHONELLA, Steinmann.

As Mr. Steinmann has not formulated a real diagnosis of the genus, but described only the single species at his disposal, we must try to find out such characters as appear of importance for the characteristic of the genus.

It may, we think, best be characterised in the following manner :—

Body elongated, more or less cylindrical, with many transverse successive furrows, by which the entire body is divided into single segments. Each segment shows a rather thick solid outer wall, which is slightly convex on the outer side, then bends inwards, becoming approximately horizontal, and then again bending down, forming thus an inner wall, and giving a ring-shaped appearance to all these segments. In such a manner a wide central tube is formed, which traverses the body for nearly its entire length and terminates at the upper extremity in a comparatively large osculum. At the base of the body of the sponge it terminates on a shelly vesicular tissue, the same tissue with which also the hollow space of each segment is either partly or entirely filled up.

The wall which thus covers the outer upper and inner side of each segment shows everywhere on its surface pores of two kinds; smaller ones which are present in very great numbers, and larger ones which are less numerous, arranged somewhat in quincunx and easily visible to the naked eye. These pores form the entrances to little canals, which pierce the substance of the wall, are mostly straight, and generally simple, only rarely bifurcating. The smaller pores also are in connection with canals, but these are mostly obliterated by the process of fossilisation. The substance of the wall is finely granular, but we were not able to distinguish any spicules. Besides this, Steinmann describes a network of dark lines between the pores and surrounding them, which we were able to observe only in a very imperfect manner.

The walls of which the vesicular tissue is made up show, on the contrary, no structure whatever. Steinmann had already observed this fact. We have figured numbers of sections, highly magnified, but there were never any pores observable. The whole wall consists of a compact shelly mass, without a trace of spicules or any other structure.

The only spicules we observed were contained in the rock that surrounds the fossil, and it is probable that they were originally imbedded in the soft parts of the animal. They are all simply fusiform spicules, sometimes curved, and often with a thorny surface. An axial canal can be distinctly observed in some cases.

One of the strangest facts in the Indian species is the existence of a kind of tabulæ within the central tube. We shall have occasion to recur to this fact.

The genus has up to the present only been found by Barrois in the carboniferous beds of Sebargas, in Asturia.

In India species belonging to the genus are of very general occurrence and have been described already by Koninck. Among the materials at our disposal we can distinguish four different species, which were all found in the middle Productus-limestone.

1. Amblysiphonella vesiculosa, Koninck, sp., Pl. CXXII, fig. 1.

1863. *Orthoceras vesiculosum*, Koninck: Quart. Journ. Geol. Soc., Lond. Vol. XIX, p. 15.
1863. *Orthoceras rachideum*, Koninck: *ibid.* p. 16.
1863. *Orthoceras rachideum*, Kon. et.
1863. *Orthoceras vesiculosum*, Kon.: Fossiles paléoz. de l'Inde, p. 5.

Already on page 67 of the present work the species here under description has been mentioned, and it was stated there that it probably belonged either to the sponges or to the Foraminifera. Upon a closer examination of the fossil we have now decided on placing it with the former.

Mons. de Koninck's description is rather incomplete and must be replaced by a new one, as the characters of the species are rather complicated.

None of the specimens at our disposal is complete. The largest of these, being but a fragment, has been figured by us, Pl. CXXII, fig. 1. It is damaged at the upper extremity as well as at the lower, but on the latter there are indications that not much is wanting. The specimen consists of about 10 or 11 segments, of rather unequal height, each very shortly cylindrical with slightly convex sides. In general they are rather regularly placed one on the other, but some are somewhat more projecting, others are placed somewhat obliquely, so that the whole specimen becomes a little curved. The height of the segments varies between 6 and 12 mm., but the latter height is the rule. Towards the lower extremity the segments become indistinct, and the whole is transformed into one vesicular mass, becoming at the same time rapidly pointed. With this lower pointed extremity the specimen was either attached to foreign bodies or inserted into mud or sand.

If we make a longitudinal or transverse section through the specimen, we find that the centre is occupied by a large cylindrical tube, whilst each segment forms a circular chamber around it. This structure led Mons. de Koninck to consider the fossil as an Orthoceras, and it must be confessed that the similarity is very great.

The tube is traversed at intervals by calcareous lamellæ, which look somewhat like tabulæ, as found in the tubes of corals; but it is rather doubtful whether in the present case these lamellæ are not of a secondary nature, cracks, caused by the drying up of the mud that once filled the tube, and afterwards infiltrated by carbonate of lime.

The central tube is lined with a rather thick wall, consisting of pieces that correspond to each single segment. The walls that separate the segments from each other are common to two successive segments and somewhat thinner. The outer wall of the segments, and thus the outer wall of the whole specimen, has been entirely lost by weathering.

In most of the chambers an irregular number of vesicles can be distinguished, which are generally attached to one of the walls or to each other; sometimes however, strange to say, they appear to be quite free. Mostly the general matrix occupies also the interior of the vesicles; in some cases, however, they are filled with a sparry matrix. Towards the base of the specimen these vesicles

augment in number, and the segments as well as the central tube are more or less obliterated.

The structure of the different parts is characteristic. The thick wall of the central tube is pierced by numerous mostly straight canals, which have a width of 0·5 to 1·5mm. The walls that separate the segments from each other are also frequently perforated, and the canals are generally 1·3mm. in diameter. The walls of the vesicles, on the contrary, are nearly always without pores, but rarely here also porous walls can be observed.

Under the microscope the walls appear always of a sparry nature and a minute structure cannot be observed.

In the rock, however, that fills the chambers, spiculæ, as well as the shells of *foraminifera*, are found. The spiculæ are fusiform or curved, always simple, sometimes with an axial canal.

The measurements of the largest specimen are as follow :—

Entire length of the specimen	110	mm.
Breadth at the upper extremity	38	„
„ „ lower „	32	„
Average height of the chambers	9	„
Width of the central tube	10-13	„

Locality and geological position.—The present species is restricted to the middle Productus-limestone, and has been found at the following localities :—At Khura in the grey limestones forming there the upper region of the middle division (2 sp.) ; and at Bilot in the compact marbly silicious limestones composing chiefly the middle region of the same division. From the same beds came apparently the specimens contained in the Geological Society's collection.

Remarks.—From Mons. de Koninck's descriptions alone it would have been rather difficult to decide what was meant under the names of *Orthoceras vesiculosum* and *rachideum*, and I should not have been able to suggest anything in this direction, had not the Geological Society of London by the liberal loan of the specimens from the Salt-range in its possession given me the opportunity to examine specimens which were labelled in Mons. de Koninck's own handwriting, and which were identical with what is now here described under the name. As the originals from which Mons. de Koninck's description was drawn up have been lost, those specimens in the Geological Society's collection may now be considered as such.

That I unite the two species distinguished by Mons. de Koninck into one, will not appear very surprising, considering the fact that the variation in the outward appearance of the several species is much greater in sponges than it is in *Cephalopoda*, and that thus the same fossils, if considered as the latter, can be easily separated into different species, whilst they have to be taken as forming only one species if considered as sponges. The differences indicated in Mons. de Koninck's descriptions as existing between the two forms cannot be considered as sufficient for the distinction of two different species in this case, and thus we have united them under the name of *Amblysiphonella vesiculosa*.

The most characteristic features of this species are that the specimens occur always simple and seem not to have grown in colonies; that the central tube is very large, and that this is enclosed by shelly parts which are very considerably thicker than the remainder of the shelly coverings occurring in the fossil. Already Mons. de Koninck has remarked this circumstance and mentions it in his description of *Orthoceras rachideum*.

The only European species of *Amblysiphonella* that has been described up to the present is *Ambl. barroisi*, Steinm., from carboniferous beds of Sebargas, in Spain. This species cannot, however, be compared to any of the Indian forms, as on a first glance its comparatively very small size distinguishes it sufficiently. But the structure is also considerably different.

2. Amblysiphonella radicifera, Waagen & Wentzel, n. sp., Pl. CXXIII, Pl. CXXIV, fig. 1.

The single individuals are more or less cylindrical and of a considerable length. There are, however, no specimens at our disposal, which are entirely free; all of them are imbedded in a compact limestone and only sections of them are exposed to view. These however are sufficiently instructive to give a complete idea of the whole fossil.

Each individual is built up of single segments, which are on an average 8mm in height and marked off from each other on the outer side of the specimens by shallow furrows. The centre of the individual is occupied by a wide central tube, which is rather irregular in its width, but which, on an average, measures also about 8mm. in diameter. Thus each segment becomes ring-shaped, its wall is fastened by its lower margin to the preceding segment, ascends for a little distance either straightly or curving a little outwards, then bending rather straightly inside and again descending to form the wall of the central tube. The thickness of the walls of the segments is everywhere the same, not more thickened along the central tube, as is the case in the preceding species. Within the hollows of each segment, vesicles of a most irregular and variable shape are developed, which either occur singly or in groups, sometimes filling the entire interior space of a segment and forming thus a regular vesicular tissue.

The structure of the individuals is not the same everywhere. The central tube disappears at a certain distance above the base, the segments become more and more irregular and are at last dissolved into a mass of irregular vesicular cells, composing often root-like appendages, and serving at the same time as a common base to several individuals, spreading out in the most irregular manner. Thus two, three, or four individuals may rise from the same basal mass of cells and diverge in different directions. Irregularities of growth can often be otherwise observed. Sometimes one sees at the upper end of an individual a second smaller tube inserted into the original central tube, which thus attains quite an irregular shape, whilst it is otherwise generally circular.

The intimate structure of the different parts is the same as in other species. The walls of the segments are everywhere pierced by numerous pores, which are 0·2—0·4mm in diameter; the vesicles, on the contrary, have mostly solid walls. In some parts of the best preserved specimen a very singular structure obtains, which has been represented on Pl. CXXIII, fig. 1f. Most of the walls and partitions appear as if double, divided in the middle by a dark stripe. This recalls very much the condition of the walls in the *Monticuliporidæ*, or of the septa in certain asteroid corals. In these latter cases the dark line has been termed "primordial wall" or "primary plate." Whether in the case of the present *Amblysiphonella* this fact has to be interpreted in a similar manner is very difficult to decide, and more observations are necessary to make out whether or not only a singular mode of preservation here obtains.

The species can attain very considerable dimensions and the single individuals may grow to a length of 150 to 200mm.; the specimens at our disposal are, however, too badly preserved to give exact measurements. The general dimensions are exactly represented by our figures.

Locality and geological position.—There were fragments of a large colony, consisting of two individuals springing from the same basal heap of cells, in Dr. Verchère's collection. The entire specimen was not sufficiently well preserved to give figures of it; a portion of it, however, has been figured by us on Pl. CXXIII. The specimen comes from the Trans-Indus continuation of the Salt-range, probably the Rotta Roh, and its rock matter shows unmistakably that it was found in the compact marbly layers of the middle Productus-limestone. Another specimen, composed apparently of only one large basal part or root from which several individuals took their origin, was collected at Virgal in the coal-beds of the middle Productus limestone.

Remarks.—The present species is rather nearly related to *Ambl. vesiculosa* described above. The differences from that species consist chiefly in the basal heap of cells and the root-like appendages it bears, in the altogether more irregular growth, and in the walls, which are throughout of equal thickness in the species here under description.

It cannot be compared to any other form.

3. Amblysiphonella multilamellosa, Waagen & Wentzel, n. sp., Pl. CXXIV, fig. 2.

It is only a comparatively small fragment that serves for the description and definition of the present species, but this shows such peculiar features that it must be considered as a distinct species.

The fragment consists of two segments, and parts of a third. Each segment is about 10mm. high and 30mm. in its transverse diameter. The fragment is traversed by a very large central tube, terminating at the upper extremity in a large round osculum, which is about 13mm. in diameter. The segments thus become of the shape of rather narrow rings of about equal height and breadth.

On the outer and upper sides of the fragment, the walls of the segments have entirely disappeared by weathering. Only where the segments are in contact with each other and along the inner side of the central tube the walls are preserved. In consequence of the absence of the outer walls, the contents of the segments are exposed to view, and it can be seen that they are crammed with vesicles. The internal structure of the fossil can, however, be better observed if sections are prepared, and we have thus figured several. The central tube appears then partly filled with rock matter, partly with crystals of carbonate of lime. The vesicles are extremely irregular, in shape as well as in size, mostly quite independent of the outer and inner walls of the segments, more or less irregularly globular. They all possess solid walls, without pores. The walls of the segments, on the contrary, are all over perforated, the pores being about 0·2 to 0·3mm. in diameter.

Locality and geological position.—The only specimen of the species available for description was collected by Mr. Wynne in the middle Productus-limestone of Morah. Another fragment, which however only doubtfully can be considered as belonging to this species, comes also from Morah.

Remarks.—The present species is rather nearly related to the two previously described, but yet shows peculiarities which forbid its union with one of these. The most characteristic features of the present form consist in the enormously wide central tube, in the comparatively thin walls that surround it, and the enormous numbers of vesicles by which the interior of the segments is filled. By these peculiarities the present species can be readily distinguished from *Ambl. vesiculosa*, as well as from *Ambl. radicifera*.

From *Ambl. barroisi*, Steinm., it can be immediately distinguished by its much larger size.

4. Amblysiphonella socialis, Waagen & Wentzel, n. sp., Pl. CXXV, fig. 2, Pl. CXXII, fig. 2.

There are only fragmentary specimens of this species at our disposal, but these show very peculiar characters.

The individuals are either single or grown together in pairs for their whole length. On the outer surface the division of the single individuals into separate segments is not distinguishable; they appear more or less smoothly cylindrical, with irregular transverse folds.

In transverse sections or natural fractures, however, the walls separating the segments from each other are often exposed to view, and it can easily be seen that in general the structure of the present species is the same as that of the previously described forms.

Peculiar to the present species are the enormously thick walls, which attain their maximum chiefly in those lining the central tube. Here the wall attains a thickness of 3·5mm., whilst the outer wall and the walls that separate the segments from each other are only 2mm. thick. The enormous development of the wall of the cen-

tral tube causes the tube itself to become very narrow, and this is another peculiarity of the species, which can be very easily recognised.

As in other species the single segments are here also hollow, and these hollow spaces are partly and irregularly filled with vesicles.

A very strange thing occurring in this species is the union of two individuals for their entire length, being laterally grown together. Where this is the case, the outer wall is common to the two individuals, so that the two can only be distinguished by deep longitudinal furrows, which run along the whole fossil on opposite sides. In transverse sections one sees that in the interiors the two individuals are separated from each other by a separate piece of wall extending from one furrow to the opposite one.

The minute structure of the walls is well distinguishable in sections, as well as on the surface of the fossils. It consists in very numerous pores, larger and smaller, of which, however, apparently only the former ones are the entrances to canals that pierce the whole wall. These have a diameter of 0·2 to 0 3mm. Very much larger are the pores that pierce the thick wall of the central tube; their diameter being from 0·75 to 1mm. The walls of the vesicles are mostly solid, as in other species.

In longitudinal sections there can be observed within the central tube some calcareous lamellæ which look like irregular tabulæ, but of which it is impossible to state whether they are original features, or whether they have been produced by the process of fossilisation.

As only fragments are at our disposal it is somewhat useless to give measurements. As, however, the dimensions are somewhat variable, we shall at least give the transverse measurements.

In the specimen, in which two individuals are grown together, we shall designate the larger individual as I and the smaller as II, whilst the single individual receives the number III.

	I.	II.	III.
Entire transverse diameter	33 mm	29 mm	22 mm
Diameter of the central tube with the wall . .	13 „	12 „	6 „
„ „ „ „ without the wall . .	7 „	4 „	3 „

Locality and geological position.—The larger of the specimens, in which two individuals are grown together laterally, is from the middle Productus-limestone (coral beds) of Virgal, where such specimens seem not to be rare (2 sp.); whilst smaller, single ones, were found at Morah and at Virgal, also in the middle Productus-limestone.

Remarks.—It is very easy to distinguish the present species from all its allies by the very narrow central canal, which is often surrounded by extremely thickened walls.

A character which is not so apparent, but which is also very peculiar, is the existence of comparatively very large canals, which pierce the wall of the central tube. This character approaches the present species to a certain extent to the genus *Sebargasia* of Steinmann. The characters of this genus are, however, still somewhat

uncertain. Steinmann distinguishes it from *Amblysiphonella* by the presence of somewhat wider canals in the walls of the central tubes, but though this character alone is barely sufficient for the distinction of a genus, yet even this is not made out with certainty, but Steinmann says that apparently such canals are present. Of greater importance seems to us the circumstance that in *Sebargasia* the vesicles, which are situated in the interior hollow space of the segments, and are of very general occurrence in *Amblysiphonella*, are entirely absent. If we take this to be the chief character of the genus, then the species here under consideration must decidedly remain with *Amblysiphonella* and cannot be placed into *Sebargasia*, as here the entire interior space of the segments is occupied by vesicles.

Family: *SPHÆROCŒLIDÆ*, Steinmann.

Steinmann characterises the family in the following manner:—

"It consists of *Pharetrones*, composed of hollow segments, which are only occasionally filled up in a peculiar manner. A central tube is absent. Walls either solid or perforated. Structure of the walls simple or double. There exists either only one large central osculum, or several smaller ones, or a large central and some smaller ones."

In this definition the indication of the walls being sometimes double has not been confirmed by our own observations. In the Salt-range there are forms very nearly related to *Sollasia*, Steinmann, which is said to possess double walls. In the Indian forms, however, not a trace of such a double structure can be observed. The irregular distribution of the black layer lining the two lower oscula in Mr. Steinmann's figures of *Sollasia*, whilst it is absent in the last one, &c., makes it not improbable that this is only a mineral deposit of a secondary origin on the inside of the walls, as we have amply figured similar things in several species of *Amblysiphonella*, for instance Pl. CXXIV, fig. 2g.

Mr. Steinmann quotes four genera in this family, but none of these is represented in the Salt-range.

The forms represented there belonging to the family compose a new genus, more or less nearly related to *Sollasia*, perhaps also to *Sphærocœlia*. We introduce for this genus the name of *Steinmannia*.

Genus: STEINMANNIA, Waagen and Wentzel, n. gen.

The individuals belonging to this genus are composed of spheroidal segments, which are all arranged in one line forming thus elongated bodies, which are generally not straight but curved in various directions. Each segment is on the outside distinctly marked off from the adjoining ones by deep furrows, so that the whole body takes an appearance like a string of large beads. If the upper surface is preserved, or if a fracture just hits the line of junction between two segments, one sees that each segment is nearly quite closed on the upper side and that only a compara-

tively small round osculum remains in the centre, by which the chambers formed by the single segments communicate with each other.

The chambers are either entirely or partly filled with vesicles.

The walls are perforated. The pores are of two sizes, smaller and large.

The individuals grow either singly or they are laterally united two or three together for their entire length.

It has been remarked above that the genus is rather nearly related to *Sollasia*, Steinm. Like the present genus, *Sollasia* also consists of a series of spheroidal chambers, in communication with each other by rather narrow oscula, which are in the centre on the top of each chamber. The distinction of two different layers within the substance of the shell, on which character great stress is laid by Dr. Steinmann, does not seem to us of great importance, as it appears rather probable that the inner layer is nothing but a mineral deposit. Nevertheless, there exists a very fundamental difference between *Sollasia* and our *Steinmannia;* as in the former genus rather numerous small ostia are irregularly distributed over each segment, which are entirely absent in the latter. Moreover, the chambers in *Sollasia* are empty whilst they are filled with vesicles in *Steinmannia*. It cannot thus be doubted that the Indian fossil must be considered as forming a different genus.

On the same plate on which *Sollasia* is represented by Dr. Steinmann yet another genus is figured which required some notice. This is *Cryptocœlia*, Steinm. This genus is in so far somewhat similar to our *Steinmannia*, as the more or less hemispherical segments are here filled with a network of somewhat radially arranged meshes, which perhaps might be compared to the vesicles occurring in the interior of the chambers of the Indian forms. The similarity is, however, only a distant one. Whilst in *Steinmannia* the vesicles have generally compact shelly walls, which are in their structure quite different from the general wall of the segments, the walls of the meshes in *Cryptocœlia* are of the same description as the outer wall of the segments, and appear more or less like processes sent out by that wall, causing the entire segments to be filled with a spongy mass. This gives a quite different character to the latter fossil and makes it necessary to place it in an entirely different family from that to which our *Steinmannia* belongs.

The genus is represented in the Salt-range by two species only, of which one occurs in the upper, the other in the middle Productus-limestone.

1. Steinmannia salinaria, Waagen & Wentzel, n. gen. et sp., Pl. CXXIV, fig. 4, Pl. CXXV, fig. 1 a. b.

The whole body is of a more or less very elongate reversedly conical, or nearly cylindrical shape, never quite straight but always slightly curved. It bears at intervals deep contractions, so that the whole appears subdivided into nearly spheroidal segments, which very slowly increase in size from bottom to top. The lowest segment is the smallest one, and it was probably attached to some foreign body.

The upper end is not known to us; but on a natural fracture that terminates our specimen in that direction, one sees that the last segment preserved almost entirely, is closed at the upper extremity, and pierced only in the centre by a small osculum. It can thus be taken for granted that each segment is similarly provided with such an osculum, and that the actual terminal segment showed an osculum on its upper extremity.

By making a longitudinal section through the specimen one sees, that each segment is closed all round, with the sole exception of the median osculum, forming a spheroidal chamber. Within these chambers vesicles, very irregular in size and shape, are more or less densely distributed, occupying, however, only rarely the entire space.

The outer surface appears ever to the naked eye densely porous. Under a lens one sees that there are two sets of pores, finer and larger, of which the former are by far more numerous. Only the latter are visible to the naked eye.

In sections, the general walls of the segments are seen to be of considerable thickness, 1·5 to 2mm. Only these are distinctly perforated, whilst the walls of the vesicles appear to be compact. Under the microscope the substance of the walls appears finely granular, but spiculæ cannot be distinguished.

It is difficult to give measurements, as only a fragment is at our disposal, in which not more than two segments are intact. The measurements of these are, however, as follow :—

Height of the first (uppermost) segment	15 mm.
Diameter „ „ „	19 „
„ „ „ segment at lower end	14 „
Height of the second segment	12 „
Diameter „ „ „	17 „
Diameter of the osculum	3 „

Locality and geological position.—There is only a single specimen of this species at our disposal. This was collected by Mr. Wynne north of Katwáhi, in the upper Productus-limestone.

Remarks.—The rather scanty materials are barely sufficient to describe the species thoroughly. Chiefly the general shape must remain rather doubtful. If one considers the section Pl. CXXIV, fig. 4*b*., at the upper extremity, an irregularity of growth is observable. To the right there is apparently a small lateral osculum and at both sides of it the commencement of a small hemispherical chamber. If this is really the case, then the species must have been arborescent, and we see here the development of a new branch. The specimen is, however, so fragmentary that one cannot become sure of the matter, though on the whole there is no great improbability that these things were really arborescent.

There is no occasion to compare the present form with any other species, as up to the present, so far as we are aware, nothing has been described that would necessitate a closer comparison.

2. Steinmannia gemina, Waagen & Wentzel, n. gen. *et* sp., Pl. CXXIV, fig. 3.

The whole fossil is elongated, laterally compressed, composed of numerous spheroidal segments in two rows, which are laterally united and in which each segment is marked off by deep furrows.

We consider the specimen as composed of two individuals, each row of segments representing one; they are laterally grown together in such a manner that the lateral wall of one of the individuals is entirely absent, this part being in common to the two.

The several segments are apparently sometimes in communication with each other by small oscula, which are, however, only rarely observable.

The interior spaces of the segments are either entirely or partly filled up by very irregular vesicles.

As in the preceding species, the walls are densely porous. The species must have attained rather considerable dimensions, but it is very difficult to make out its exact shape and extension, as it is always enclosed in massive, compact limestones, where the shape of the fossils can only be studied in sections. As far as the measurements can at all be taken, they seem to be as follow:—

Average height of the segments	10 mm.
Greatest diameter „ „	14 „
Smallest „ „ „	10 „
Diameter of the oscula (if present)	2 „
Diameter of the two individuals	27 „

Locality and geological position.—The only specimen of this species from the Salt-range is preserved in a piece of compact limestone from Dr. Verchère's collection; it is probably from the Rotta Roh, and evidently came from the middle division of the Productus-limestone.

Remarks.—The materials of the present species are yet by far more inadequate than those of the preceding one, but as this form occurs at certain localities in great numbers, though it be never possible to detach it from the rock, and takes part in the formation of the coral reefs that are met with here and there in the middle Productus-limestone, we thought it not advisable to pass it entirely in silence.

Individuals up to two, three, or perhaps even more, are laterally united, forming thus thick, vertical lamellar expansions, which curve in various directions, and apparently sometimes send off branches. Thus complicated colonies are formed, which can attain considerable dimensions.

From the preceding species, the present one is distinct by the more slender shape of the single individuals and by the remarkable lateral union of several such individuals.

Sub-Kingdom: **PROTOZOA.**

By Dr. CONRAD SCHWAGER of MUNICH.

Class: RHIZOPODA.

Order: FORAMINIFERA.

Family: *NUMMULINIDÆ.*

Sub-Family: *FUSULININÆ.*

Genus: FUSULINA, D'Orb.

Of the names quoted at the head of this paper, only the one belonging to the order requires some remark, in explanation of my having used the name *Foraminifera* of D'Orbigny in preference to others. By other authors the name *Thalamophora* is generally used, but this seems to me a very inadequate one, as it could just as well be employed for *Cephalopoda* with a chambered shell. The same remarks may be applied to the term *Reticularia*, which has also been used by some. Thus, among the names given to the order of old the one introduced by D'Orbigny, when calling it *Foraminifera*, is the least objectionable. But even this one is not in all cases quite appropriate, and I rather feel inclined to propose a new name, *Thalamoprotista*, which more adequately than the others expresses the peculiarities of the order.

As regards the systematic arrangement of the forms more or less nearly related to *Fusulina* proper, it is rather difficult to decide what way of proceeding ought to be adopted. For the present it seems best to follow the arrangement used by H. B. Brady, who characterises the genus *Fusulina* in the following manner:—

"Test fusiform or subglobular, chambers entire, or only subdivided by the infolding of the septal wall, aperture an elongated central fissure."

If the diagnosis is framed so, those forms that have been separated from *Fusulina* under the name of *Schwagerina* do not fall within the scope of it, but must be kept separate. The relation between the two groups is, however, a very close one, and even the infolding of the septal walls occurs in certain species of the last genus at the umbilical ends. Nevertheless, a distinction of the two genera can always be effected without great difficulty, partly by the general aspect exhibited by the different forms of *Schwagerina*, partly, as has been indicated already by Brady, by the existence of true secondary septa. The latter character is, however, not always equally strongly developed, and just the globular forms, which are otherwise the most characteristic ones, show it only in a rather rudimentary state. Even *Schwagerina lepida*, Schw., at the first glance, rather similar to *Fusulina robusta*, Meek, can easily be recognised as belonging to the genus, if both forms be put side by side.

The case is a different one with *Fusulinella*, Möller, another form most nearly related to *Fusulina* proper. According to Möller, this genus is chiefly characterised

Schwager: Carbonische Foraminiferen aus China u. Japan: Richthofen's China, Vol. IV, pp. 109—118.

by the external wall simply bending down to form the septal walls. Brady has taken *Fusulinella* to form nothing but a subgenus of *Fusulina;* but it seems to me that such a position would not quite rightly indicate the real affinities. There are certain forms of *Fusulinella* which in their general habitus can barely be distinguished from *Schwagerina*. At the same time, there exist in some of the species at both sides of the aperture, which are otherwise similar to the aperture of *Fusulina*, thickenings which are extremely similar to those most characteristic for *Schwagerina*, and thus it seems to me more advisable to approach *Fusulinella* to *Schwagerina* rather than to *Fusulina*.

Though we thus arrive at satisfactory results with regard to the distinction of genera, the same can hardly be said with regard to the distinction of species. The question might even be raised in this respect whether different species can be at all distinguished, and, if so, what limits ought to be given to them.

We all agree that in Nature real limits to the single forms do not exist, and that all distinctions we introduce are to a certain extent of a more or less artificial kind. The more we become acquainted with the different forms of organic life, the more we get convinced that all is chained together in the most manifold manner, the links running sometimes parallel, sometimes crossing each other, but always one joining the other. If we now, in such a net-work of chains, want to make distinctions,—and distinctions we *must* make for practical purposes,—this cannot possibly be done without cutting the links to the right and left; that is to say, without ignoring the transitional forms that link our species to those to the right and the left. Thus the species will always be abstractions to a certain extent; but what part of natural science can do without abstractions? Even mathematics, as soon as they are applied to natural objects as in geometry, astronomy, or natural philosophy, cannot do without them. Even these start from the supposition of the equality of things which are not equal in reality. They ignore to a certain extent variations that must occur in nature and arrive at such abstractions just as well as other branches of natural science do. But as, nevertheless, those mathematic disciplines have arrived at such irrevocable results, so we may hope that also biology, if proceeding in the same way, may at last arrive at results, which may be of similar value. Just as the laws, by which nature is governed, have been detected in prosecuting those mathematic disciplines, so the laws which are followed in the development of organisms will at last be unravelled by biology. But long and consequent labour in comparative anatomy, physiology, and palæontology will be needed before those laws can be fixed in so far as to be put into ruling sentences.

I have exposed in one of my former publications my views in this respect, and have tried to show that each species can be considered as forming a mathematic formula, in which the components are the forces which have been at work for the formation of the species. These forces must, however, from the beginning be divided in two different sets, the morphogenetic and the physiological forces, and this distinction is absolutely necessary if we want to arrive at formulæ, which ought to be

of any value. The first which find their expression in the characters of the species are of overwhelming importance, whilst the latter are only of secondary value. In the formulæ, which we thus suppose to exist, some of the components appear as variable, others as constant, and the constants will evince more or less considerable resistance if the form of any organic being is attacked, be it by the influence of outward circumstances or other causes.

If, however, the external influences are stronger than the constants existing in the organism, then these must give way. But at the same time the equilibrium of forces which beforehand existed in such an organism is then considerably shaken, a new arrangement must take place, and it not rarely occurs that just one of those characters, which up to then had to be considered as variable, now takes up the place of one of the constants, or that one or all of the former constants are reduced to the rank of variables. In the meantime, before a new state of equilibrium of forces be attained, a species will be subject to manifold variations, whilst the variations will be by far less considerable if equilibrium is again established.

Starting from such considerations, we cannot overestimate the local influences the organisms are subject to, and any system that wishes not only to register the single forms but to treat them in their natural affinities, as well as in their distinctive characters, must take heed of their local relations in time as well as in space. To illustrate this by an example, I may adduce the fact that, if we put—to return directly to the forms here under consideration—the *Fusulinæ*, a species from Russia, at the side of one from North America, join to these again one from China and one of Texas, we may compose in such a way a line of perfect transition from one extreme to the other, but it is very doubtful whether a natural affinity is so established. If, on the contrary, we consider each of the above forms with regard to their local surroundings, each appears as a perfectly separated form, which is most easily recognisable.

I am thus of opinion that the local relations of the single forms must never be neglected in the description and separation of species, and chiefly in forms like the *Fusulinæ*. Where an external sculpture is entirely absent, these local relations are of the utmost importance. The more minutely the distinctions are made in local faunas, without of course ever neglecting also the general affinities, the more safe will be the conclusions we will be able to draw from such minutely described fossils in regard to geological questions, and from this point of view also I have treated the species of the Salt-range.

1. Fusulina Kattaensis, Schwag. n. sp., Pl. CXXVI, figs. 1—11; Pl. CXXVIII, fig. 4.

Shell straightly sub-fusiform, laterally slightly tapering, with twisted and more or less rounded ends. Proportion of the greatest length to the greatest breadth in general 10mm : 2·2mm. Septal plane at both sides spreading out and upraised in the

midst; at the base strongly plicated, so that neighbouring folds join tightly together. Chambers narrow in the median part, somewhat bent to the front; in young specimens nearly quite flat, in full-grown ones generally rather vaulted. Sutural lines well marked, in the beginning less so. Average number of chambers in the last volution 25. Embryonal chamber large, globular, or ellipsoidal. Series of altitudes of the volutions 2·22, 2, [1] 7·5, 12, 21, 23, 25. Average increase of the diameters of the shell wall 2, 2 1, 4, 6, 7, 8. Average diameter of the pores in the last whorl 0·12 to 0·16mm. The measured width of the orifice in the last turn is for the most part $\frac{1}{8}$ of the length of the shell.

Locality and geological position.—As type of this species I consider those specimens that come from the upper region of the lower Productus-limestone of Katta, and which have been represented in figs. 1 and 2 of Pl. CXXVI. Specimens from Chidroo, also from the lower Productus-limestone are most probably identical with the typical form. It is not the same with other specimens from Katta which have been found somewhat lower down in the series. These, if more extensive materials were procurable, could, perhaps, be considered as a distinct variety or sub-species, for which the name *sub-Kattaensis* might do.

Remarks.—Among all the species of *Fusulina* hitherto described there is none with which the present species could specially be compared, except that perhaps the not yet full-grown more slender specimens have a certain similarity with the typical *Fus. cylindrica* from Miatschkowa. If however one does not use only single select specimens for comparison, but lays the greater stress on the general appearance of the majority of specimens, it will be seen that the great frequency of nearly cylindrical forms is a character which is never to be found among specimens of the Miatschkowa species. A comparison also of the microscopical sections of the present species as drawn by me, with those represented by Möller of *Fus. cylindrica* will show directly that there cannot be any doubt about the distinctness of the two species. A third point of importance is the average size, which is very different in the two species.

We have indicated above that at Katta there exist two different layers containing *Fusulinæ*. The specimens from the upper layer we consider as composing the typical *Fus. Kattaensis*, whilst the specimens from the lower layer seem to deviate from the typical form to a certain extent. These latter are, however, mostly more or less deformed by pressure, and thus a close comparison is made difficult. The one point, however, can always be ascertained, that both ends are generally more paraboloid in their outline, whilst they are more abbreviated in the typical form. Also the increase of the whorls is a different one.

In mentioning these Katta fossils we must lastly also point out a peculiarity of the pores, which first struck us on these things, but was afterwards also detected on the typical specimens. This peculiarity has been figured, Pl. CXXVI, figs. 10

[1] These first three numbers indicate always the reciprocal diameters of the walls and the interior space of the embryonal chamber.

and 11, and consists in the fission observable in the external walls of the last chambers of the canals that communicate with the pores, which occurs often with such regularity that one must suppose it to be the normal state. Fig. 10 has been drawn with the utmost care by means of the camera lucida, and there cannot be any doubt about the matter.

2. Fusulina Pailensis, Schwager, n. sp., Pl. CXXVII, figs. 1—7.

Shell elongately fusiform, or transversely elliptic in outline, with blunt and moderately twisted ends. Proportion of the length to the breadth of the shell 13mm. to 1·7mm. Chambers in the middle part of the shell rarely considerably arched, recurved towards the ends, in the beginning nearly flat, the rest but little vaulted. Sutural lines clearly visible on the last whorl, shallow, but sharply defined. Septal plane tolerably enlarged towards the ends. Embryonal chamber remarkably small. Relative proportions of the embryonal chamber and succeeding whorls generally 1·2, 9, 1·2, 3·2, 4·2, 5, 7, 23. The increase of the shell-wall is as follows: 1·2, 1·4, 1·5, 2·2, 3·5, 4·8. Diameter of the pores in the last whorl 0·08mm. Aperture sub-elliptical, and occupying $\frac{1}{14}$ of the entire length.

Locality and geological position.—This species has, up to the present, been detected only at a single locality, Pail, where it fills the whole rock with millions of specimens. It occurs there towards the upper region of the lower Productus-limestone associated with *Spirifer Marcou*, W.

Remarks.—There are only rock-specimens of a very hard nature in which the present species is enclosed. The whole rock is crowded with specimens, which are in very good preservation, though, on account of the hardness of the surrounding rock-matter, it is mostly only possible to detach the fossils in a quite fragmentary condition from the matrix. Nevertheless, the preservation is so excellent that it was not found difficult to distinguish the present species from the preceding one.

In its general outline and its size the present species shows a certain resemblance to some forms from the upper carboniferous limestone of North America, which are generally quoted under the name of *Fusulina cylindrica*. The form from Missouri seems most similar, though this one is also slightly more slender. With the typical *Fusulina cylindrica* from Miatchkowa in the Moskow basin, there exists only a rather distant similarity. These external similarities might arouse some doubts whether it was quite justifiable to make a new species out of the Indian fossils. These doubts are, however, dissipated as soon as we compare the internal structures of the different forms. In opposition to all the others, the Indian form is characterised by an extraordinarily small embryonal chamber. By this character it can also be easily distinguished from *Fus. Kattaensis* described before. Besides this, there is also the general outline, a different form. Fig. 1*a*, Pl. CXXVII, represents the normal state, the shape which most frequently is met with; whilst fig. 1*c* represents a shape which is of comparatively rare occurrence.

As in all *fusulinæ*, so also in this species the range of variation chiefly finds its expression in the relative length of the shell. On the whole, it seems not very difficult to distinguish the present species from *Fus. Kattaensis ;* but according to my view the species cannot as yet be considered as fully established as long as its geological relations to *Fus. Kattaensis* on the one hand and *Fus. longissima* on the other are not yet quite distinctly made out.

3. Fusulina longissima, Möller, Pl. CXXVII, figs. 7—12; Pl. CXXVIII, figs. 1—3.

1878. *Fusulina longissima*, Möller: Die spiral gewundenen Foraminiferen des russischen Kohlenkalks: Mém. Acad. imp. St. Petersb. VII, Ser. Tome XXV, Nr. 9, p. 59, Pl. I, fig. 4, Pl. II, fig. 1, Pl. VII, fig. 1.

Shell, in the young state, mostly lengthened fusiform; when full-grown nearly cylindrical, often crooked, with rounded sometimes slightly inflated ends. Chambers numerous, unequal; in the beginning almost flat, at last vaulted. In the midst, they are a little arched, coiling at the considerably twisted ends. Size of the septal plane at the lateral ends variable. Mean rate of increase of the whorls 3, 25, 3, 6 5, 11·5, 16, 20·5, 28, 33. Mean rate of increase of the thickness of the chamber-walls, 3, 2·6, 3·2, 5, 6·5, 7·2, 7·8. Aperture in general $\frac{1}{9}$ of the length of the shell. Diameter of the pores in the last whorl 0·12mm.

Locality and geological position.—The typical form of this species has been represented by us on Pl. CXXVII, and the specimens which are there figured all come from the lowest beds of the lower Productus-limestone of the Verala scarp. Together with the typical form, specimens also occur in the same locality which are more tapering towards the ends, or others which more resemble fig. 1 on Pl. CXXVIII. The originals, which are represented on this latter plate, are taken from a red sandstone, collected by Mr. Wynne at Omarkheyl, and which beyond doubt forms there also part of the lower Productus-limestone. Further specimens have been procured from the lower Productus-limestone of the Nila, Wan, and Pail.

Of all the species of *Fusulina* occurring in the Salt-range this one holds the lowest geological position, occurring in the first fossiliferous beds above the lavender clays of the speckled sandstone (Wynne), or even yet followed by a certain thickness of these clays.

Remarks.—Though the present form shows some slight differences from the typical Russian specimens found at the Shiguli mountains, &c., yet these seem to us not sufficiently large to warrant a specific distinction between the two forms. The chief character, which is, however, well developed in the full-grown state, only consists in the very great length of the shell in comparison to its breadth, and this character is most distinctly exhibited by many of the Indian specimens. Nevertheless it cannot be denied there are also other specimens which show a less strong elongation, though also in these the specific character can always be recognised.

The various curving of the shell, a character peculiar to the Indian specimens, gives to these bodies somewhat the appearance of a caterpillar; and if in time, perhaps, a specific distinction of the Indian form should be necessary, the name of *Fus. erucaria* would be a very appropriate one. Among the Indian specimens, the range of variation chiefly finds expression in the conformation of the lateral ends, which are sometimes paraboloid, sometimes more shortly rounded. Size and general appearance are, however, always approximately the same.

By far more difficult is the distinction of the not yet full-grown specimens, as a considerable proportion of these approaches *Fus. Pailensis* rather nearly. From the outward appearance, a distinction would be nearly impossible; but the inner structure of the two species is entirely different. Notwithstanding the great variability of the internal characters of *Fus. longissima*, which has been noticed already by Möller, there is one character which constantly holds good; this is the size of the embryonal chamber. This latter organ is always considerably larger in *Fus. longissima* than it is in *Fus. Pailensis*, and thus there is no difficulty in distinguishing them. Another fact is that *Fus. longissima* grows to a much more considerable size than is ever the case with *Fus. Pailensis;* and, as in the *Fusulinæ*, the size is of great importance for the distinction of species; this character must be considered as an important one.

Among the Indian materials there are specimens which reach quite extraordinary dimensions. There is a specimen from Omarkheyl in which the proportion of the longitudinal to the transverse diameter is 16mm., 2·2mm; another specimen from Verala scarp shows the proportion 12mm., 2·4mm. The transverse diameter of 3mm. exhibited by the specimen represented fig. 9, Pl. CXXVII, suggests even yet larger dimensions. These are considerably larger sizes than have been observed by Möller, whose largest specimen showed the proportions of 11mm., 2·5mm.

4. Fusulina, sp., indet., Pl. CXXVIII, fig. 5*a*. *b*.

With even greater right than the preceding one, the present form should perhaps bear the name of *Fus. longissima;* but the materials at hand were too scanty to decide the question. As far as the characters of the present form can be made out, they seem to be the following: shell long, nearly cylindrical, straight, with tolerably twisted and shortly rounded ends. Average dimensions probably 9mm., 1·2mm. Chambers nearly straight up to very near the ends; the folds of neighbouring chambers fused together. The average number of chambers in one volution is probably 15.

Locality and geological position.—The few specimens procured of this species were collected at Bhal in beds very low down in the lower Productus-limestone series.

Remarks.—In general appearance, the present form is very near the preceding one; it can, however, be distinguished by its greater slenderness and the straightness

of its shell, which is very marked in comparison with the curvature of *Fus. longissima*.

Sub-genus: FUSULINELLA, Möller.

This group is, as has been already remarked in the introduction, very well characterised by the circumstance that the outer wall passes uninterruptedly into the septal walls. At the same time, the present sub-genus possesses the greatest vertical distribution among the forms belonging to the family *Fusulinidæ*. The range of variation of form within the genus is also rather great.

1. FUSULINELLA WAAGENI, Schwager, n. sp., Pl. CXXVIII, figs. 10*a*—*c*.

Though but a single specimen of this species was discriminated by my investigations, it is nevertheless so singularly well preserved that I can venture to found the distinction of a proper species on this single individual. As far as the characters could be observed by me, they might serve for the drawing up of the following diagnosis.

Shell lenticular in general out-line, with rounded margins and subconical lateral faces. Chambers but little vaulted, only the final ones more strongly arched. Centre of the disc as well as the septal lines covered by an umbilical callosity. Orifice unknown. The specimen measures from margin to margin (longitudinal diameter) 0·9mm., and from one lateral face to the other (transverse diameter) 0·44mm.

Locality and geological position.—The specimen was procured by me from some chips that were taken by Dr. Waagen off a specimen of *Prod. Indicus*, collected by Mr. Wynne at Khoond Ghât in the middle region of the upper Productus-limestone.

Remarks.—The present species shows a very close affinity to *Fusulinella Struvi*, M., a well-known species of the lower carboniferous beds of Russia. This affinity is a remarkable one, the Indian form being of so very much more recent geological age. But though such an affinity exists, a distinction between the two forms is not difficult. The chief distinctive character is the absence of a depression along the margins, which is so strongly marked in *Fus. Struvi*, without speaking of the umbilical callosity and the callous covering of the septa, which give *Fus. Waageni* form a characteristic appearance.

Family: *LAGENIDÆ*.

Sub-Family: *NODOSARINÆ*.

Genus: LINGULINA, D'Orb.

It is not without interest to meet with a representative of the present group of *Foraminifera* in the Indian beds, though in the *Bellerophon* beds of the Southern Alps several similar forms have been already observed, yet it is not before the Lias

that the chief development of the genus takes place; whilst only later on a strict difference between the *Frondicularinæ* and the *Lingulinæ* is developed. The presence of a species of *Lingulina* in the India palæozoic strata is so much the more remarkable as typical forms of *Nodosarinæ* do not generally make their appearance before Permian times.

1. LINGULINA DECIPIENS, Schwager, n. sp., Pl. CXXVIII, figs. 11*a*—*d*.

Shell, viewed laterally, broadly wedge-shaped; with a more or less strongly prominent rounded crest along the middle, from which the shell descends slightly and evenly towards the margins. The lateral contours, caused by a slight protruding of the chambers are provided with wavy indentations. The upper termination probably forms a kind of parallelogram with rounded corners and sides. The chambers are tolerably broad; in the beginning nearly flat, later on somewhat vaulted; in the middle but little elevated, the last ones even somewhat depressed. Laterally the chambers bend considerably downward. The sutures are in the beginning barely perceptible, but later on become strongly defined.

The measurements are as follow :—

Greatest length	0·032mm.
„ breadth	0·031mm.
„ thickness	0·006mm.

The shell is pierced by large rather closely arranged pores. The orifice was not visible on any of the specimens at our disposal.

Locality and geological position.—The specimens were detected by me in some fragments of rock that came from the upper Productus-limestone of Khoond Ghât.

Remarks.—The name *L. decipiens* has been employed for this species on account of the circumstance that the general outline, as is shown by the drawings, if alone taken into consideration, would easily cause an observer to consider it as a *Textularia*. As soon as the internal structure, however, is known, its position with *Lingulina* cannot be subject to any doubt. The upper termination, as it has been drawn on the plate, has not been directly observed, but has been restored according to analogy.

On account of the range of variation within the species it is not possible to say much, as only few individuals are at my disposal. So much, however, might perhaps be said that the proportion of the length to the breadth is somewhat, though not very, variable. In the height of the chambers slight differences are also observable.

Family: *LITNOLIDÆ*.

Sub-Family: *ENDOTHYRINÆ*.

Genus: INVOLUTINA Terqnem.

This genus also is not generally met with earlier than the Lias. So much the more interesting is it to find a species of the genus here in palæozoic strata.

Its preservation is not quite excellent, but always sufficiently so for recognition of the genus with certainty: hence we have thought it worthy of description.

1. INVOLUTINA CARBONICA, Schwager, n. sp., Pl. CXXVIII, figs. 7—9.

If I give a special name to the specimens here under consideration, it is chiefly on account of their geological position, because otherwise these bodies are barely distinguishable from *Involutina liassica*, Terg. What makes the distinctness chiefly probable is the absence of similar forms in the intermediate formations.

Locality and geological position.—The specimens of this species were procured by me from some fragments of rock that adhered to a specimen of *Bellerophon*, collected by Mr. Wynne in the upper Productus-limestone of Khoond Ghât.

Genus: MARGARITINA, Schwager, n. gen.

We let this new genus follow here without asserting either that it belongs to the *Foraminifera* or even to the *Protozoa;* but as these forms had been united by former describers with those groups, the materials were sent to me, and now I am obliged to give a description.

The present form has been always compared to *Saccamina carteri* from lower carboniferous beds, and it can barely be denied that there exist very near relations to that fossil form, at least in outward appearance. The genus *Saccamina* has lately been excellently described from recent specimens and figured by Brady in his admirable description of the *Foraminifera* collected by the Challenger-expedition. That learned author has, however, already expressed the opinion that the Indian fossils were something very far different from the recent genus, and I perfectly concur with him in this respect. My minute investigations of the Indian materials have brought to light many facts pointing in this direction; but, at the same time, the very near analogies with *Saccamina*, which nevertheless exist, are very remarkable.

As far as I could make out the characters, they can be comprised in the following diagnosis:—

Shell consisting of more or less fusiform or barrel-shaped pieces, which, chiefly in the young state, are ranged one behind the other, like a string of beads, assuming such an appearance, very much like the shell of a *Nodosaria*. In the full-grown state the single pieces are mostly separate. Each of them is provided with two orifices, which are situated at the opposite ends in the longer axis. The substance of the shell is pierced by more or less regularly arranged pores. In a normal state the shell seems to be made up entirely of calcareous matter; but this does not prevent that—exceptionally perhaps in some forms—also foreign bodies should be made use of for the completion of the shell, and thus be embodied in the shell substance. The thickness of the shell is comparatively moderate; but it must be remarked that it is somewhat unequal, which would indicate the existence of some ruggedness or unevenness on the interior shell-surface. Whether any kind of hard tissues

partly filled the interior space of the fossil cannot for the present be decided; but we shall see in the description of the species that such a thing is not improbable.

1. Margaritina Schwageri, Zittel, sp., Pl. CXXVIII, figs. 12—15.

1876. *Saccamina Schwageri*, Zittel: Hand b. d. Palæontologie I. 1. p. 76, fig. 8 Nr. 5.

There were, on the whole, only single examples of the fossil at disposal for description; only in a single case, in preparing a slide for microscopic inspection, was it observed that several such pieces, gradually diminishing in size, were strung together, forming a body very much like the shell of a *Nodosaria*. The single pieces that otherwise generally occur are either thickly fusiform or sometimes also somewhat more elongated; rarely they are barrel-shaped. The two largest diameters of these pieces show on an average the proportion of 7·5mm., 5mm. There are, however, also specimens, which measure 8·5mm. in height and 9·5mm. in breadth.

Very characteristic of these bodies is the relief with which the outer surface of the shell is covered. It consists of generally six, rarely five sided pits, separated from each other by little edged ridges, and bearing in the middle a small pore (compare fig. 13 f). The diameter of these pores may, in young specimens, be as small as 0·025mm.; in full-grown specimens it is generally 0·09mm. Only in the specimen represented in fig. 15, Pl. CXXVIII, which we consider as a separate variety; the diameter of the pores is as much as 0·13mm. That the shelly surroundings of the pores are of a thoroughly calcareous nature, and that the centre of the six-sided spaces is really occupied by a pore, can easily be ascertained by treating the specimens with dilute acid, whereby the calcareous shell-substance is dissolved, and the rock-matter by which the pores were filled then shown in relief. In this way it was also possible to ascertain that the pores pierce the shell-substance directly and straightly.

In a specimen that has been figured, Pl. CXXVIII, fig. 13*e*, I found a concave plate closing the orifice. This plate is distinguished from the remainder of the shell by its large pores, the diameter of which is about twice the diameter of the pores of the remainder of the shell. This plate is the immediate continuation of the outer wall of the whole fossil, and the direct union of the two could be observed with all possible distinctness. There remains only some doubt whether towards the centre of this plate the pores have been rightly observed.

By far more problematic are those substances that seem to occupy and partly fill the interior space of the shell. I have tried to represent some of my observations in figs. 13*b*, *c*, and *d*, but must confess that these seem to me barely definitive, and it will be necessary to make new studies on better preserved materials. Just as it has been observed by Brady in his *Saccamina*, so also I found most of the specimens simply filled with rock-matter or with calc-spar. There are, however, other cases, which are not quite so exceptional, in which a calcareous substance fills the whole shell, which on a closer examination manifests itself as of a cystoid nature. In this, however, the walls of the single cysts are only distinguishable by a some-

what darker colour. That this appearance is not accidental is shown by the intimate connection of the walls of the cyst with the outer walls of the shell and chiefly with the plate that closes the orifice. Even yet stranger is the further observation, that in specimens which are somewhat impregnated with oxide of iron, one can, under very high magnifying powers, distinguish within the walls of the cysts something like the spicules of sponges, which seem to be mostly arranged in ring-like groups. If such preparations are treated with dilute acid, the spicules become yet more distinctly visible. In making such observations the circumstance must never be lost sight of, that in the rather unsatisfactory condition in which fossils generally are, parasitic organisms are very easily taken as forming original features of fossil bodies; also that in *Margaritina* such parasitic organisms exist. This is beyond doubt in some cases, but with regard to the facts expounded above, such an explanation seems barely admissible, as the great regularity with which the spicules have been observed to occur in several specimens, and the distinctness with which they are arranged and distributed make it highly probable that we have to deal here with original features of these organisms. A further affirmation of this view is obtained by the study of the specimen represented in fig. 14, in which the interior of one of the pieces is exposed to view by weathering and in which a singular structure is observable, on the whole not in contradiction to what has been observed by me in thin sections. To follow the matter further is impossible for the present. We must await the inspection of better materials, which are more strongly impregnated with oxide of iron, before all these questions can be finally decided. In the meantime, the structure, as it has been described by me, appears at least so far deviating from the type of the *Foraminifera*, that the position of the genus *Margaritina* even among the *Protozoa* must be strongly doubted.

Locality and geological position.—The species is not at all rare in the upper division of the Productus-limestone. The greatest number of well-preserved specimens has been collected by Dr. Waagen in the top beds of the upper Productus-limestone of Virgal and Chidru. A piece of rock, containing numbers of specimens of this species, were brought by Mr. Wynne from Khoond Ghât out of the lower beds of the upper Productus-limestone. The geologically oldest specimen was found by Dr. Waagen in the Lower Productus-limestone of Katta. This specimen, however, shows several peculiarities, chiefly exceptionally large pores, and I therefore consider it as constituting a different variety.

Remarks.—If the present species, as has been stated above, does not belong to the *Protozoa*, the question arises, where else ought it to be placed; but this question is much more easily raised than answered. The occurrence of spicules in the interior tissues of the fossil seems to point in the direction of the sponges; but before we can be sure in this respect, yet many other facts ought to be ascertained. On the whole, the greatest analogy seems for the moment to be with the *Pharetrones*, Sub-order *Sphinctozoa*, with which these fossils may, perhaps, be placed in a provisional way.

ALPHABETICAL INDEX

OF

GENERA AND SPECIES.

ACANTHOCLADIA, King, 811.
anceps, Schloth., sp., 812.
ALLORISMA, King, 192.
dubium, Waag., n. sp., 196.
perelegans, Waag., n. sp., 193.
pleuromyoides, Waag., n. sp., 195.
sp. indet., 196.
AMBLYSIPHONELLA, Steinmann, 972.
multilamellosa, Waag. & Wentzel, n. sp., 976.
radicifera, Waag. & Wentzel, n. sp., 975.
socialis, Waag. & Wentzel, n. sp., 977.
vesiculosa, Koninck, sp., 973.
AMPLEXUS, Sow., 901.
abichi, Waag. & Wentzel, n. sp., 903.
cristatus, Waag. & Wentzel, n. sp., 902.
ANTALE, Aldrovand, 182.
sp. indet., 182, 183.
ARÆOPORA, Nicholson, 837.
ramosa, Waag. & Wentzel, 839.
tuberosa, Waag. & Wentzel, 838.
ARCESTES, Suess, 26.
antiquus, Waag., n. sp., 28.
priscus, Waag., n. sp., 30.
ASTARTE, Sow., 211.
ambiensis, Waag., n. sp., 211.
ATHYRIS, M'Coy, 471.
acutomarginalis, Waag., n. sp., 482.
ambiguæformis, Waag., n. sp., 473.
capillata, Waag., n. sp., 479.
cf. pectinifera, Sow., 485.
cf. royssii, Léveillé, 478.
globulina, Waag., n. sp., 484.
grossula, Waag., n. sp., 474.
royssü, Léveillé, 475.
semiconcava, Waag., n. sp., 481.
subexpansa, Waag., n. sp., 478.
ATOMODESMA, Beyrich, 273.
indicum, Waag., n. sp., 274.
AULOSTEGES, Helmersen, 661.
dalhousii, Davidson, 662.
medlicottianus, Waag., n. sp., 663.
AVICULA, Klein, 289.
chidruensis, Waag., n. sp., 290.
AVICULOPECTEN, M'Coy, 300.
asiaticus, Koninck, 316.
crebristriatus, Koninck, sp., 311.
derajatensis, Waag., n. sp., 304.
jabiensis, Waag., n. sp., 303.
katwahiensis, Waag., n. sp., 313.
morahensis, Waag., n. sp., 308.
pseudoctenostreon, Waag., n. sp., 306.
squamula, Waag., n. sp., 315.
subexoticus, Waag., n. sp., 309.

BELLEROPHON, Montfort, 133.
affinis, Waag., n. sp., 141.
blanfordianus, Waag., n. sp., 142.
cf. blanfordianus, Waag., 144.
BELLEROPHON—*continued.*
impressus, Waag., n. sp., 139.
jonesianus, Koninck, 135.
orientalis, Koninck, 147.
politus, Waag., n. sp., 148.
squamatus, Waag., n. sp., 138.
BUCANIA, Hall, 150.
angustifasciata, Waag., n. sp., 152.
integra, Waag., n. sp., 153.
kattaensis, Waag., n. sp., 151.
ornatissima, Waag., n. sp., 155.

CAMEROPHORIA, King, 435.
globulina, Phill., 443.
humbletonensis, Howse, 440.
pinguis, Waag., n. sp., 441.
purdoni, Davidson, 437.
superstes, Verneuil, 445.
CARDINIA, Agassiz, 209.
conjungens, Waag., n. sp., 209.
CARDINOCRANIA, Waag., n. gen., 745.
indica, Waag., n. gen. et sp., 746.
CARDIOMORPHA, Koninck, 190.
indica, Waag., n. sp., 191.
CARTERINA, Waag. & Wentzel, n. gen., 944.
pyramidata, Waag. & Wentzel, n. gen. et sp., 945.
CHONETELLA, Waag., n. gen., 657.
nasuta, Waag., n. gen. et sp., 658.
CHONETES, Fisch. v. Waldh., 614.
æquicosta, Waag., n. sp., 639.
ambiensis, Waag., n. sp., 618.
avicula, Waag., n. sp., 622.
bipartita, Waag., n. sp., 624.
compressa, Waag., n. sp., 630.
deplanata, Waag., n. sp., 637.
dichotoma, Waag., n. sp., 633.
grandicosta, Waag., n. sp., 638.
morahensis, Waag., n. sp., 620.
semiovalis, Waag., n. sp., 632.
squama, Waag., n. sp., 626.
squamulifera, Waag., n. sp., 634.
strophomenoides, Waag., n. sp., 628.
trapezoidalis, Waag., n. sp., 623.
CIRCOPORA, Waag. & Wentzel, n. gen., 957.
faveolata, Waag. & Wentzel, n. gen. et sp., 958.
tubulosa, Waag. & Wentzel, n. gen. et sp., 960.
CLEIDOPHORUS, Hall, 224.
striatulus, Waag., n. sp., 228.
trapezoidalis, Waag., n. sp., 227.
CYATHOCRINUS, Mill., 822.
goliathus, Waag., n. sp., 823.
indicus, Waag., n. sp., 826.
kattaensis, Waag., n. sp., 828.
virgalensis, Waag., n. sp., 825.
CYCLOLOBUS, Waag., n. gen., 21.
oldhami, Waag, 24.
CYTHERE, Müller, 20.
cf. elongata, Münster, 21.

Davidsonella, Waag., n. gen., 762.
linguloides, Waag., n. gen. et sp., 764.
squama, Waag., n. gen. et sp., 766.
Derbyia, Waag., n. gen., 591.
altestriata, Waag., n. gen. et sp., 600.
grandis, Waag., n. gen. et sp., 597.
hemisphærica, Waag., n. gen. et sp., 604.
plicatella, Waag., n. gen. et sp., 601.
vercherei, Waag., n. gen. et sp., 602.
regularis, Waag., n. gen. et sp., 594.
" " var. minor, 597.
Dielasma, King, 336.
acutangulum, Waag., n. sp., 353.
biplex, Waag., n. sp., 349.
breviplicatum, Waag., n. sp., 356.
elongatum, Schloth., sp., 342.
guttula, Waag., n. sp., 340.
itaitubense, Derby, sp., 348.
minor, Waag., n. sp., 346.
nummulus, Waag., n. sp., 344.
problematicum, (Dav.) Waag., n. sp., 351.
truncatum, Waag., n. sp., 345.
Dielasmina, Waag., n. gen., 359.
plicata, Waag., n. gen. et sp., 360.
Discinolepis Waag., n. gen., 749.
granulata, Waag., n. gen. et sp., 750.
Disjectopora, Waag. & Wentzel, n. gen., 947.
milleporæformis, Waag. & Wentzel, n. gen. et sp., 948.
Dolabra, M'Coy, 257.
arcina, Waag., n. sp., 258.
corbina, Waag., n. sp., 259.
Dybowskiella, Waag. & Wentzel, n. gen., 916.
expansa, Waag. & Wentzel, n. gen. et sp., 921.
grandis, Waag. and Wentzel, n. gen. et sp., 919.

Entalis, Gray, 180.
herculea, Koninck, sp., 181.
Enteletes, Fisch. v. Waldh., 550.
acuteplicatus, Waag., n. sp., 562.
ferrugineus, Waag., n. sp., 556.
kayseri, Waag., n. sp., 553.
lævissimus, Waag., n. sp., 554.
latesinuatus, Waag., n. sp., 559.
pentameroides, Waag., n. sp., 561.
sublævis, Waag., n. sp., 558.
Eocidaris, Desor., 818.
forbesiana, Koninck, sp., 819.
Eucharis, Recluz, 188.
grandæva, Waag., n. sp., 189.
Euchondria, Meek, 326.
sub-pusilla, Waag., n. sp., 326.
Eumetria, Hall, 487.
grandicosta, (Dav.) Waag., 491.
indica, Waag., n. sp., 493.
Euomphalus, Sow., 86.
parvus, Waag., n. sp., 89.
pusillus, Waag., n. sp., 91.
Euphemus, M'Coy, 163.
apertus, Waag., n. sp., 168.
indicus, Waag., n. sp., 166.
lævis, Waag., n. sp., 169.
lenticularis, Waag., n. sp., 170.
Fenestella, Lonsdale, 776.
jabiensis, Waag. & Pichl., n. sp., 778.
perelegans, Meek, 777.
sp. indet.

Fistulipora, M'Coy, 922.
parasitica, Waag. & Wentzel, n. sp., 923.
Fusulina, D'Orb., 983.
kattaensis, Schwager, n. sp., 985.
longissima, Möller, 988.
pailensis, Schwager, n. sp., 987.
sp. indet., 989.

Fusulinella, Möller, 990.
waageni, Schwager, n. sp., 990.
Geinitzella, Waag. & Wentzel, n. gen., 880.
columnaris, Schloth., sp., 882.
crassa, Lonsdale, sp., 884.
Goniocladia, R. Etheridge, jun., 804.
indica, Waag. & Pichl., 805.
Gouldia, Adams, 212.
primæva, Waag., n. sp., 213.
Gyroceras, Koninck, 64.
medlicottianum, Waag., n. sp., 65.

Helodopsis, Waag., n. gen., 13.
abbreviata, Waag., n. gen. et sp., 15.
elongata, Waag., n. gen. et sp., 14.
Hemiptychina, Waag., n. gen., 361.
crebriplicata, Waag., n. gen. et sp., 374.
himalayensis, Davidson, sp., 368.
inflata, Waag., n. gen. et sp., 372.
sparsiplicata, Waag., n. gen. et sp., 366.
sub-lævis, Waag., n. gen. et sp., 364.
Hexagonella, Waag. & Wentzel, n. gen., 911.
lævigata, Waag. & Wentzel, n. gen. et sp., 915.
ramosa, Waag. & Wentzel, n. gen. et sp., 912.
tortuosa, Waag. & Wentzel, n. gen. et sp., 914.
Holopella, M'Coy, 93.
trimorpha, Waag., n. sp., 94.
Hydriocrinus, Trantschold, 829.
sp. indet., 830.
Hyolithes, Eichwald, 175.
orientalis, Waag., n. sp., 177.
sp. indet., 178.

Involutina, Terquem, 991.
carbonica, Schwager., n. sp., 992.
Ireregulatopora, Waag. & Wentzel, n. gen., 951.
undulata, Waag. & Wentzel, n. gen. et sp., 952.

Leptæna, Dahn. (emend. Davids.), 609.
indica, Waag., n. sp., 609.
Liebea, Waag., n. gen., 292.
indica, Waag., n. gen. et sp., 295.
Lima, Brug., 297.
footei, Waag., n. sp., 298.
Lingula, Bruguière, 768.
kiurensis, Waag., n. sp., 768.
warthi, Waag., n. sp., 769.
Lingulina, D'Orb., 990.
decipiens, Schwager, n. sp., 991.
Lithodomina, Waag., n. gen., 264.
abbreviata, Waag., n. gen. et sp., 267.
typa, Waag., n. gen. et sp., 266.
Lithodomus, Cuvier, 268.
atavus, Waag., n. sp., 269.
Lonsdaleia, M'Coy, 892.
indica, Waag. & Wentzel, n. sp., 897.
salinaria, Waag. & Wentzel, n. sp., 895.
virgalensis, Waag. & Wentzel, n. sp., 900.
wynnei, Waag. & Wentzel, n. sp., 896.
Loripes, Poli, 206.
atavus, Waag., n. sp., 207.
proavius, Waag., n. sp., 208.
Lucina, Brug., 203.
bombifrons, Waag., n. sp., 205.
progenitrix, Waag., n. sp., 204.
Lythonia, Waag., n. gen., 396.
cf. richthofeni, Kays, sp., 403.
nobilis, Waag., n. gen. et sp., 398.
tenuis, Waag., n. gen. et sp., 401.

Macrocheilus, Phillips, 96.
avellanoides, de Koninck, 97.
Macrodon, Lycett, 254.
geminum, Waag., n. sp., 255.

MACROTHECA, Waag., n. gen., 178.
wynnei, Waag., n. gen. et sp., 179.
MARGARITA, Leach, 111.
prisca, Waag., n. sp., 111.
MARGARITINA, Schwager, n. gen., 992.
schwageri, Zittel, sp., 993.
MARGINIFERA, Waag., n. gen., 713.
eclimata, Waag., n. gen. et sp., 727.
excavata, Waag., n. gen. et sp., 715.
ornata, Waag., n. gen. et sp., 721.
ovalis, Waag., n. gen. et sp., 723.
transversa, Waag., n. gen. et sp., 725.
typica, Waag., n. gen. et sp., 717.
MARTINIA, M'Coy, 528.
cf. glabra, Martin, sp., 531.
chidruensis, Waag., n. sp., 535.
elongata, Waag., n. sp., 532.
semiplana, Waag., n. sp., 536.
warthi, Waag., n. sp., 533.
MARTINIOPSIS, Waag., n. gen., 524.
inflata, Waag., n. gen. et sp., 525.
subpentagonalis, Waag., n. gen. et sp., 527.
MICHELINIA, Koninck, 848.
abichi, Waag. & Wentzel, n. sp., 850.
cf. glomerata, M'Coy, 854.
indica, Waag. & Wentzel, n. sp., 853.
placenta, Waag. & Wentzel, n. sp., 852.
MODIOLA, Lamk., 270.
transparens, Waag., n. sp., 270.
MOGULIA, Waag., n. gen., 156.
regularis, Waag., n. gen. et sp., 157.
MONOTRYPA, Nicholson, 875.
mastoidea, Waag. & Wentzel, n. sp., 876.
MURCHISONIA, Arch. & Vern., 122.
conjungens, Waag., n. sp., 125.
MYOPHORIA, Bronn., 241.
cardissa, Waag., n. sp., 244.
præcox, Waag., n. sp., 243.
sub-elegans, Waag., n. sp., 246.
MYTILUS, Linn., 271.
patriarchalis, Waag., n. sp., 272.
NATICOPSIS, M'Coy, 99.
indica, Waag., n. sp., 101.
khurensis, Waag., n. sp., 100.
NAUTILUS, Linn., 42, 85.
connecteus, Waag., n. sp., 60.
convolutus, Waag., n. sp., 62.
flemingianus, Koninck, 48.
goliathus, Waag., n. sp., 50, 85.
latissimus, Waag., n. sp., 56.
multituberculatus, Waag., n. sp., 51.
ophioneus, Waag., n. sp., 58.
peregrinus, Waag., n. sp., 47.
transitorius, Waag., n. sp., 53.
wynnei, Waag., n. sp., 55.
NEOBOLUS, Waag., n. gen., 756.
warthi, Waag., n. gen. et sp., 758.
wynnei, Waag., n. gen. et sp., 759.
NERITOMOPSIS, Waag., n. gen., 106.
minuta, Waag., n. gen. et sp., 107.
ovulum, Waag., n. gen. et sp., 108.
NOTOTHYRIS, Waag., n. gen., 375.
djoulfensis, Abich., sp., 379.
inflata, Waag., n. gen. et sp., 384.
lenticularis, Waag., n. gen. et sp., 385.
minuta, Waag., n. gen. et sp., 386.
multiplicata, Waag., n. gen. et sp., 388.
simplex, Waag., n. gen. et sp., 389.
subvesicularis, Davidson, sp., 378.
warthi, n. gen. et sp., 382.
NUCULA, Lamk., 250.
trivialis, Eichwald, 253.
ventricosa. Hall, 251.
NUCULANA, Link, 248.
sub-acuta, Waag., n. sp., 248.
OLDHAMINA, Waag., n. gen., 403.
decipiens, Koninck, sp., 406.
ORBIPORA, (Eichwald), Dybowsky, 877.
ambiensis, Waag. & Wentzel, n. sp., 878.
ORTHIS, Dahn, 563.
corallina, Waag., n. sp., 572.
derbyi, Waag., n. sp., 565.
incisiva, Waag., n. sp., 574.
indica, Waag., n. sp., 568.
janiceps, Waag., n. sp., 570.
marmorea, Waag., n. sp., 566.
pecosii, Marcou, 573.
ORTHOCERAS, Breyn, 66.
cyclophorum, Waag., n. sp., 68.
oblique-annulatum, Waag., n. sp., 69.
punjabiense, Waag., n. sp., 71.
sp. indet., 72.
ORTHOTHETES, Fischer v. Waldheim, 607.
semiplanus, Waag., n. sp., 608.
OXYTOMA, Meek, 286.
atavum, Waag., n. sp., 287.
PACHYPORA, Lindström, 844.
curvata, Waag. & Wentzel, n. sp., 846.
jabiensis, Waag. & Wentzel, n. sp., 847.
PALANATINA, Hall, 198.
indica, Waag., n. sp., 200.
PECTEN, Klein, 317.
flemingianus, Koninck, 325.
præcox, Waag., n. sp., 318.
prototextorius, Waag., n. sp., 321.
sub-granosus, Waag., n. sp., 323.
wynnei, Waag., n. sp., 320.
PETALORHYNCHUS, Agassiz, 17.
indicus, Waag., n. sp., 17.
PHASIANELLA, Lamk., 109.
arenicola, Waag., n. sp., 109.
PHILOCRINUS, Koninck, 832.
cometa, Koninck, 833.
PHYLLOPORA, King, 796.
cribellum, Koninck, 798.
haimeana, Koninck, 799.
jabiensis, Waag. & Pichl., n. sp., 797.
PLATYSTOMA, Conrad, 103.
indicum, Waag., n. sp., 105.
PLEUROPHORUS, King, 214.
acuteplicatus, Waag., n. sp., 223.
complanatus, Waag., n. sp., 220.
imbricatus, Koninck, sp., 217.
sub-ovalis, Waag., n. sp., 219.
PLEUROTOMARIA, Defr., 113.
durga, Waag., n. sp., 119.
kattaensis, Waag., n. sp., 121.
punjabica, Waag., n. sp., 115.
sequens, Waag., n. sp., 118.
PŒCILODUS, Agassiz, 11.
paradoxus, Waag., n. sp., 12.
POLYPORA, M'Coy, 781.
biarmica, Keyserling, 791.
gigantea, Waag. & Pichl., n. sp., 786.
koninckiana, Waag. & Pichl., n. sp., 783.
megastoma, Koninck, sp., 785.
ornata, Waag & Pichl., n. sp., 788.
sykesi, Koninck, sp., 789.
transiens, Waag. & Pichl., n. sp., 795.
vermicularis, Waag & Pichl., n. sp., 793.
POTERIOCRINUS, Mill., 830.
sp. indet., 831.
PRODUCTUS, Sowerby, 666.
abichi, Waag., n. sp., 697.
aratus, Waag., n. sp., 684.
asperulus, Waag., n. sp., 693.
bhalensis, Waag., n. sp., 704.
compressus, Waag., n. sp., 710.
cora, Orbigny, 677.
cylindricus, Waag., n. sp., 702.

PRODUCTUS—*continued.*
gratiosus, Waag., n. sp., 691.
humboldti, Orbigny, 695.
indicus, Waag., n. sp., 687.
lineatus, Waag., n. sp., 673.
mytiloides, Waag., n. sp., 711.
opuntia, Waag., n. sp., 707.
purdoni, Davidson, 705.
semireticulatus, Mart., 679.
serialis, Waag., n. sp., 700.
spiralis, Waag., n. sp., 681.
subcostatus, Waag., n. sp., 685.
tumidus, Waag., n. sp., 708.
vishnu, Waag., n. sp., 690.
PSAMMODUS, Agassiz, 16.
sp. indet., 16.
PSEPHODUS, Agassiz, 73.
depressus, Waag., n. sp., 75.
indicus, Waag., n. sp., 73.
PSEUDOMONOTIS, Beyrich, 276.
deplanata, Waag., n. sp., 285.
garforthensis, King, sp., 278.
gigantea, Waag., n. sp., 283.
inversa, Waag., n. sp., 284.
kazanensis, Vern., 281.
radialis, Phillips, sp., 280.

RETICULARIA, M'Coy, 538.
elegantula, Waag., n. sp., 545.
indica, Waag., n. sp., 542.
lineata, Mart., sp., 540.
RHOMBOPORA, Meek, 963.
obliqua, Waag., n. sp., 964.
polyporata, Waag., n. sp., 965.
RHYNCHONELLA, Fischer v. Waldheim, 430.
morahensis, Waag., n. sp., 433.
sp. indet., 434.
wynnei, Waag., n. sp., 432.
RICHTHOFENIA, Kayser, 733.
lawrenciana, Koninck, sp., 736.
sinensis, Waag., 742.

SAGECERAS, Mojsisovics, 37, 81.
hauerianum, Koninck, 39.
primas, Waag., 39.
wynnei, Waag., n. sp., 81.
SCHIZODUS, King, 230.
compressus, Waag., n. sp., 240.
dubiiformis, Waag., n. sp., 238.
pinguis, Waag., n. sp., 236.
rotundatus, Brown, sp., 233.
SCHIZOPHOLIS, Waag., n. gen., 752.
rugosa, Waag., n. gen. et sp., 753.
SEPTIFER, Recluz, 261.
squama, Waag., n. sp., 262.
SERPULITES, Murchison, 816.
indicus, Waag., n. sp., 817.
SIGMODUS, Waag., 9.
dubius, Waag., n. sp., 10.
SPENGLERIA, Tryon, 185.
vetusta, Waag., n. sp., 187.
SPHÆRIOLA, Stoliczka, 201.
grandæva, Waag., n. sp., 202.
SPIRIFER, Sowerby, 507.
alatus, Schloth., sp., 519.
ambiensis, Waag., n. sp., 515.
marcoui, Waag., n. sp., 510.
musakheylensis, Davidson, 512.
niger, Waag., n. sp., 522.
oldhamianus, Waag., n. sp., 518.
striatus, Martin, sp., 509.
wynnei, Waag., n. sp., 517.
SPIRIFERINA, Orb., 498.
cristata, Schloth, 499.
multiplicata, Sow., sp., 502.
nasuta, Waag., n. sp., 504.

SPIRIFERINA—*continued.*
ordata, Waag., n. sp., 504.
vercherei, Waag., n. sp., 506.
SPIRIGERELLA, Waag., n. gen., 450.
alata, Waag., n. gen. et sp., 470.
derbyi, Waag., n. gen. et sp., 453.
" " var. acuteplicata, 456.
fusiformis, Waag., n. gen. et sp., 467.
grandis, (Davidson), Waag., 461.
hybrida, Waag., n. gen., et sp., 459.
media, Waag., n. gen. et sp., 465.
minuta, Waag., n. gen. et sp., 460.
numismalis, Waag., n. gen. et sp., 469.
ovoidalis, Waag., n. gen. et sp., 466.
prælonga, Waag., n. gen. et sp., 457.
SPIRORBIS, Daudin, 814.
helix, King, 815.
STACHELLA, Waag., n. gen., 171.
bifrons, Waag., n. gen. et sp., 173.
semiaurita, Waag., n. gen. et sp., 174.
STEINMANNIA, Waag. & Wentzel, n. gen., 979.
gemina, Waag. & Wentzel, n. gen. et sp., 982.
salinaria, Waag. & Wentzel, n. gen. et sp., 980.
STENOPORA, Lonsdale, 885.
chæteliformis, Waag. & Wentzel, n. sp., 890.
hemisphærica, Waag. & Wentzel, n. sp., 891.
nicholsoni, Waag. & Wentzel, n. sp., 889.
ovata, Lonsdale, 888.
STREPTORHYNCHUS, King, 577.
capuloides, Waag., n. sp., 582.
deltoideus, Waag., n. sp., 585.
distortus, Waag., n. sp., 590.
lenticularis, Waag., n. sp., 581.
operculatus, Waag., n. sp., 583.
pectiniformis, Davidson, 587.
pelargonatus, Schloth., sp., 579.
STROPHALOSIA, King, 640.
costata, Waag., n. sp., 655.
excavata, Geinitz, 642.
horrescens, Vern., 643.
indica, Waag., n. sp., 648.
nodosa, Waag., n. sp., ,652.
plicosa, Waag., n. sp., 650.
rarispina, Waag., n. sp., 645.
tenuispina, Waag., n. sp., 654.
SYNOCLADIA, King, 801.
virgulacea, Phill., sp., 802.

TEREBRATULOIDEA, Waag., n. gen., 413.
davidsoni, Waag., n. gen. et sp., 416.
depressa, Waag., n. gen. et sp., 419.
minor, Waag., n. gen. et sp., 420.
ornata, Waag., n. gen. et sp., 423.
THAMNATACANTHUS, Waag., n. gen., 78.
blanfordi, Waag., n. gen. et sp., 79.
THAMNISCUS, King, 807.
dubius, Schloth, sp., 808.
serialis, Waag. & Pichl., n. sp., 810.

UNCINELLA, Waag., n. gen., 494.
indica, Waag., n. gen. et sp., 495.
UNCINULUS, Bayle, 424.
jabiensis, Waag., n. sp., 427.
posterus, Waag., n. sp., 428.
theobaldi, Waag., n. sp., 425.

WARTHIA, Waag., n. gen., 158.
brevisinuata, Waag., n. gen. et sp., 161
lata, Waag., n. gen. et sp., 162.
polita, Waag., n. gen. et sp., 160.

XENODISCUS, Waag., n. gen., 32.
carbonarius, Waag., n. gen. et sp., 35.
plicatus, Waag., n. gen. et sp., 34.
XYSTRACANTHUS, Leidy, 18, 76.
giganteus, Waag., n. sp., 76.
gracilis, Waag., n. sp., 19.
major, Waag., n. sp., 19.

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